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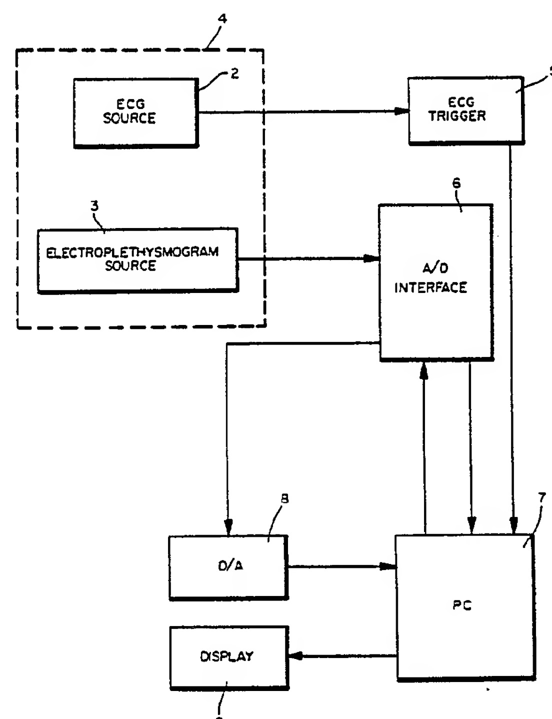
(54) Title: METHODS AND APPARATUS FOR MONITORING CARDIOVASCULAR REGULATION USING HEART RATE POWER SPECTRAL ANALYSIS

(57) Abstract

A patient monitor (4) having an electrocardiographic signal source (2) and an electroplethysmographic respiratory signal source (3) provides inputs to an ECG trigger circuit (5) and an analog-to-digital interface respectively which in turn provide data and control signals to a personal computer (7) programmed to automatically correct the data for artifacts and analyze the spectral densities of the signals which are then shown on display (9).



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METHODS AND APPARATUS FOR MONITORING CARDIOVASCULAR REGULATION USING HEART RATE POWER SPECTRAL ANALYSIS

Background of the Invention

The present invention relates in general to methods and apparatus for monitoring cardiovascular regulation and in particular to methods and apparatus for heart rate spectral analysis.

Changes in cardiovascular regulation associated with congestive heart failure include attenuation of activity in the parasympathetic division of the autonomic nervous system, enhancement of activity in the sympathetic division of the autonomic nervous system, cardiac catecholamine depletion, down regulation of the beta-receptor system, increased renin-angiotensin system activity, and alteration of baroreceptor function. All of these regulatory changes require either specific clinical manipulations, such as a stress test, a Valsalva maneuver, or the like, and/or invasive maneuvers, such as cardiac biopsy, plasma catecholamine measurement, or the like, in order to determine the extent of regulatory dysfunction and its impact upon the clinical state of the patient and upon prognoses for the patient. These procedures are time consuming, and generally do not permit the formation of a clinical judgment and subsequent action within the timeframe of the course of treatment for critically ill patients in an Intensive Care Unit.

Fluctuations from heartbeat to heartbeat in measured properties of the circulatory system reflect both the presence of a variety of naturally occurring

physiological disturbances of the circulatory system homeostasis, and the dynamic response of cardiovascular control systems to these disturbances. For example, the cyclic variation in intrathoracic pressure which accompanies breathing mechanically affects the return of venous blood to the heart and also affects blood pressure in pulmonary vessels and in the aorta. The variation in intrathoracic pressure is also coupled to a cyclic variation in heart rate through a neural mechanism mediated by the central nervous system. Furthermore, the resulting cyclic variation in arterial blood pressure impinges on heart rate through a reflex, known as the baroreceptor reflex, which is mediated by the autonomic nervous system. Disturbances in cardiovascular homeostasis also occur with fluctuations in the resistance of peripheral blood vessels as vascular beds regulate local blood flow to match supply with demand. These fluctuations in peripheral resistance may perturb central blood pressure and, through the baroreceptor reflex, may also lead to a compensatory variation in heart rate.

Many types of medical instruments exist for studying heart rate variability. The instantaneous rate-meter is perhaps the earliest such instrument. This meter measures each RR interval through analog or digital circuitry and displays the instantaneous heart rate.

An improvement in the rate-meter is achieved by performing first order statistical evaluation on the RR-intervals. With mini- and micro-computer systems, histogram displays of RR-interval differences may be generated along with their mean and standard deviations.

Another technique for heart rate variability analysis involves the study of spectral content of the instantaneous heart rate time series. In one approach to spectral analysis in animals, the computations are

done on a computer. Akselrod, et al., <u>Science</u>, <u>213</u>, 220-222 (1981) Hyndman, et al., <u>Automedica</u>, <u>1</u>, 239-252 (1975). Such systems analyze data recorded on magnetic or punched tape. However, not only do these systems introduce additional errors during the recording process, they do not perform in real time. Furthermore, these systems are not multichannel in nature.

A Sparse Discrete Fourier Transform algorithm which may be implemented on a personal computer (CBM 2016) and which may perform on-line monitoring of heart rate variability, based on a low pass filtered cardiac event series is disclosed in Rompelman, et al., <u>IEEE Trans. Biomed. Engineering,</u> <u>BME-29</u>, 503-510 (1982). A specialized hardware device also exists for low pass filtering the cardiac event series by a stepwise convolution to create the low pass filtered cardiac event series. Coenen, et al., <u>Medical and Biological Engineering and Computing</u>, <u>15</u>, 423-430 (1977). Nevertheless, these instruments posses a limited band width and a limited frequency resolution capability.

There exists a need for an instrument which provides multi-channel spectral analysis of an instantaneous heart rate and of a respiratory activity time series. There also exists a need for an instrument wherein such calculations are performed in real time at the bedside.

Summary of the Invention

An apparatus according to the present invention corrects artifacts in a series of heartbeats. Means for collecting a series of heartbeat samples are coupled to means for determining a mean interval between heartbeats. Means for identifying a mean variance among the intervals between heartbeats samples are coupled to means for establishing an

acceptable of slewing rates as a function of the mean variance. Means for particularizing the absolute value of the slewing rate of a heartbeat sample relative to the mean interval are coupled to the means to determining and means for substituting the mean interval between heartbeats for all heartbeat interval samples having an absolute outside the range of acceptable slewing rates are coupled to the means for particularizing.

A method according to the present invention corrects artifacts in a series of heartbeats. A series of heartbeat interval samples is collected and an appropriate interval between heartbeats is determined. Variances in the intervals between heartbeats are identified and an acceptable range of slewing rates is established as a function of a mean variance. An absolute value of the slewing rate of a heartbeat sample relative to the mean interval is particularized. An appropriate interval is substituted for all heartbeat interval samples having an absolute value outside the range of acceptable slewing rates.

Apparatus according to the present invention calibrates a heart rate power spectrum monitor. Means for supplying a signal simulating a heart rate, means for generating a signal simulating a respiratory frequency fluctuation in heart rate and means for providing a signal simulating a low frequency fluctuation in heart rate are coupled to means for applying signals from these means to a heart rate power spectrum analyzer.

Apparatus according to the present invention performs heart rate fluctuation power spectral analysis. Means for providing an electrocardiogram signal and means for supplying electroplethysmogram signal are coupled to means for obtaining a heart rate fluctuation power spectrum from an electrocardiogram

signal and from an electroplethysmogram signal. Real time means for displaying a heart rate fluctuation power spectrum are coupled to the means for obtaining.

Apparatus according to the present invention trends heart rate fluctuation power spectral data. Means for providing an electrocardiogram signal and the means for supplying an electroplethysmogram signal are coupled to means for obtaining a heart rate fluctuation power spectrum from an electrocardiogram signal and from an electroplethysmogram signal. Means for storing heart rate fluctuation power spectral data are coupled to means for obtaining. Addressable means for transmitting stored heart rate fluctuation power spectral data are coupled to the means for storing and means for converting heart rate fluctuation power spectral data into graphic form are coupled to the addressable means for transmitting. Real time means for displaying heart rate fluctuation power spectra are coupled to the means for converting.

A method according to the present invention treats conditions related to malfunctions of the cardiovascular control system. A power spectrum of heart rate fluctuations in the patient are monitored. A level below about 0.1 (beats/min.)^2 in the power spectrum of heart rate fluctuations is identified at a frequency between about 0.04 and about 0.10 Hz as indicative of cardiovascular instability. Procedures are applied to treat the condition and thereby to increase the level of heart rate fluctuations at a frequency between about 0.04 and about 0.10 Hz.

A method according to the present invention treats conditions related to malfunctions of the cardiovascular control system in a patient. A power spectrum of heart rate fluctuations is monitored in the patient. A marked increase to above about 10 (beats/min.)^2 in heart rate fluctuations at a frequency

between about 0.04 to about 0.10 Hz is identified as indicative of cardiovascular stress. Procedures are applied to treat the condition and thereby to decrease the level of heart rate fluctuations between about 0.04 and about 0.10 Hz.

Yet another method according to the present invention treats conditions related to malfunctions of the cardiovascular control system in a patient. A power spectrum of heart rate fluctuations in the patient is monitored. A ratio of the area under a heart rate power spectrum peak at a frequency between about 0.04 and 0.10 Hz to the area under a peak in the respiratory power spectrum centered at the mean respiratory rate about 0.1 Hz is identified as having an absolute value less than 2.0 for longer than or equal to about one hour as indicating of cardiac instability. Procedures are applied to treat the condition and thereby to increase the ratio.

Still another method according to the present invention treats conditions related to malfunctions of the cardiovascular control system in a patient. A power spectrum of heart rate fluctuations in the patient is monitored. A ratio of the area under a heart rate power spectrum peak at a frequency between about 0.04 and 0.10 Hz to the area under a peak in the respiratory power spectrum centered at the mean respiratory rate about 0.1 Hz is identified as having an absolute value greater than or about 50 as indicating of cardiac instability. Procedures are applied to treat the condition and thereby to increase the ratio.

Brief Description of the Drawings

Fig. 1 illustrates low frequency, mid-frequency and high frequency in the power spectrum of heart rate fluctuations in a dog according to the

prior art;

Fig. 2 illustrates aspects of the cardiovascular control system according to the prior art;

Fig. 3 is a block diagram of apparatus for heart rate fluctuation power spectral analysis according to the present invention;

Fig. 4 illustrates address buffers and address decoding in a data acquisition device according to the present invention;

Fig. 5 illustrates components according to the present invention for interfacing an ECG apparatus with a personal computer according to the present invention;

Fig. 6 illustrates a digital to analog converter according to the present invention;

Fig. 7 illustrates a ECG trigger according to the present invention;

Fig. 8 illustrates a portable calibrator according to the present invention;

Figs. 9A and B are halves of a flow chart for software applicable to an embodiment of the present invention on a IBM personal computer;

Fig. 10 illustrates a trend for a stable patient according to the present invention;

Fig. 11 illustrates a trend display for an unstable patient according to the present invention;

Fig. 12 is an illustration of an instantaneous heart rate according to the present invention;

Fig. 13 is an illustration of an instantaneous heart rate fluctuation spectrum of the sort obtainable from apparatus according to the present invention;

Fig. 14 is a stable patient's heart rate fluctuation power spectrum according to the present invention;

Fig. 15 is an unstable patient's heart rate fluctuation power spectrum according to the present

invention;

Fig. 16 depicts distributions in LFP data obtained according to the present invention for stable and for unstable patients;

Fig. 17 graphically depicts distributions of RFP data according to the present invention for stable and for unstable patients; and

Fig. 18 graphically depicts data for LFP/RFP ratios according to the present invention for stable and for unstable patients.

Detailed Description

Power spectral methods may be used to analyze the frequency content of fluctuations in heart rate and other hemodynamic parameters. Hyndman, et al., Nature, 233, 339-341 (1971); Sayers, Ergonomics, 16, 17-32 (1973). Short term (i.e., on a time scale of seconds to minutes) fluctuations in these parameters are concentrated in three principal spectral peaks as illustrated for a canine model in Fig. 1. Akselrod, et al., *supra.* One peak is centered at the respiratory frequency; this peak shifts with changes in the respiratory rate. The second identifiable spectral peak, the mid-frequency peak, occurs typically between 0.1 and 0.15 Hz. The oscillations associated with this second peak occur at 6-9 cycles per minute, a considerably lower frequency than the respiratory frequency, and are related to the frequency response of the baroreceptor reflex. The third peak of the spectrum typically occurs in the frequency band of 0.04 to 0.10 Hz. This low frequency peak is related to thermoregulatory fluctuations in vasomotor tone.

In one approach to the spectral analysis of heart rate, properties of the heart rate fluctuations in the conscious dog may be related to the activity of

three cardiovascular control systems - the parasympathetic nervous system, the sympathetic nervous system and the renin-angiotensin system. Akselrod, et al., Science, 213, 220-223 (1981). This model is further elaborated in Akselrod, et al., "Hemodynamic Regulation: Investigation by Spectral Analysis " (In Press). Heart rate fluctuations occurring at frequencies above roughly 0.1 Hz are mediated solely by the parasympathetic system. Blockade of the renin-angiotensin system leads to a dramatic increase in the amplitude of the low frequency peak. The effects of an autonomic blockade also exist in humans and changes in body posture alter sympathetic-parasympathetic balance as measured by the heart rate power spectrum. Pomeranz, et al., Am. J. Physiol., 248, H151-H153 (1985).

A simple model of the short term cardiovascular control system is illustrated in Fig. 2. Akselrod, et al., supra. In this model, heart rate is directly modulated by the sympathetic and parasympathetic nervous systems. Through a variety of receptors both these systems sense, fluctuations in cardiovascular parameters including arterial and venous pressures, vascular volumes, and correlates of blood flow and oxygenation. The parasympathetic system may respond over a wide frequency range while the sympathetic system may only respond at relatively low frequencies below roughly 0.1 Hz.

A hypothesis was proposed in Akselrod, et al., Science, 213, 220-223 (1981), that fluctuations in vasomotor tone associated with the low frequency heart rate fluctuations are not solely related to thermoregulation but also reflect local adjustment to resistance in individual beds of blood vessels in order to match local blood flow to local metabolic demand. Such fluctuations in peripheral vasomotor tone lead to

fluctuations in central blood pressures which are in turn sensed by pressoreceptors. Stimulation of these pressoreceptors occasions an autonomically mediated baroreceptor reflex, which leads to compensatory fluctuations in heart rate at the corresponding frequency. In addition, the renin-angiotensin hormonal system senses blood pressure fluctuations and, through the elaboration of a substance called angiotensin II, plays the role of the guardian of the overall peripheral vascular resistance. Blockade of the renin-angiotensin system by a converting enzyme inhibitor, may remove this damping influence and may permit increased fluctuations in blood pressure and increased compensatory fluctuations in heart rate in the low frequency regime.

The critically ill infant or child prior to, during, and after cardiac surgery at times exhibits marked changes in heart rate, blood pressure, and peripheral perfusion. These changes may be of no clinical consequence or they may indicate the existence of a major unrecognized pathology whose first outward manifestation may be sudden cardiac arrest. To be able to quantify cardiovascular regulatory reserve permits objective assessment of a patient's cardiovascular stability as well as their response to medical and surgical interventions intended to improve cardiovascular function.

Spectral analysis of tape-recorded records of ECG and respiratory activity from patients with complex congenital heart diseases and myocarditis reveals peculiarities in low frequency heart rate fluctuations not seen in studies of healthy children and adults. In particular: (1) low levels of low frequency heart rate fluctuations are noted for critically ill patients in congestive heart failure, which levels revert to normal after surgical or medical treatment and (2) a marked increase in low frequency heart rate fluctuations is

observed in patients with otherwise undetected cardiac tamponade.

A transitional microprocessor-based monitoring instrument, which utilized a Z-80 microprocessor and a S-100 bus, was constructed along with a data acquisition system which interfaced the microprocessor with a Hewlett-Packard 78341 patient monitor.

A prototype system is described in Jerome C. Tu, "Microprocessor System for Real-Time Spectral Analysis Physiological Signals," Master of Department of Electrical Engineering and Computer Sciences, Science Thesis, Massachusetts Institute of Technology (1984). An electrocardiogram (ECG) was inputed into a the data acquisition system from a patient monitor for this prototype system.

In the data acquisition system, the analog voltage signal of the ECG was applied to the input of a variable frequency voltage-controlled oscillator in the data acquisition system. A counter coupled to the output of the VCO provided a digital representation of the voltage associated with the ECG peaks. The largest voltage peak, called the R voltage peak and associated in the ECG with ventricular contraction, was used to trigger a clock. Each R peak loaded the value of the clock into a holding register and restarted the clock. The value of the clock provided a measure of the heart rate as the inverse of the time between beats. (i.e., as the RR internal)

The regular respiratory signal of a patient on a ventilator was employed to obtain a respiratory spectrum and was similarly obtained through a VCO The respiratory frequency had to be manually entered in order to establish a fixed window for computing the power in the heart rate power spectrum in the respiratory peak.

Every 256 seconds the digitized ECG RR

intervals were inputed into the microprocessor from the data acquisition system. A smoothed heart rate "tachometer wave form" was created as follows: (1) the instantaneous heart rate time series was computed from the stored RR intervals; (2) a 1024 point time series of the instantaneous heart rate was computed from the stored instantaneous heart rate time series by sampling the latter at 4 Hz; (3) the mean heart rate computed from the 1024-point time series of instantaneous heart rate was subtracted from the smoothed series resulting in a "tachometer waveform". The heart rate power spectrum was computed from the heart rate "tachometer waveform" as follows: (1) a 1024-Point Fast Fourier Transform was computed using 1024 points of the tachometer cardiac tachometer waveform; and (2) the heart rate power spectrum was computed by squaring the absolute value of the previously calculated transform.

As new data was inputted into the computer's buffer, the results of the smoothed cardiac tachometer signal, power spectrum and integral of power spectrum were outputted onto a printer. Thus, for every 256-second time interval, a spectral representation of the preceding 256 seconds of instantaneous heart rate data was exhibited.

From the above data, the area under the low frequency peak (LFP) between 0.04 and 0.1 Hz and the area under the respiratory frequency peak (RFP) within a peak width window of 0.2 Hz were determined. Trend graphs of LFP, RFP, and LFP/RFP ratio were created. The 256 second data segments were rejected if, (1) the patient was not in sinus rhythm; (2) transients and/or artifact were present on the cardiac "tachometer wave form"; and (3) the LFP/RFP ratios were greater than 2 standard deviations from the mean for the study period.

The practical problems associated with this prototype monitoring instrument included the extremely

tedious calculations required for use of the prototype with free-breathing patients and the large amount of data (as much as 50%, in some instances) which had to be discarded due to the presence of motion artifacts. These artifacts resulted from virtually any disturbance of the patient, even a disturbance so slight as holding the patient's hand. The prototype system had no capacity to identify or reject artifacts or to examine the data for dropped beats and premature triggers.

Upon reviewing clinical studies performed using the prototype, it was discovered that not only were attenuated low frequency heart rate fluctuations associated with a severely compromised regulatory reserve but also that the ratio of the power in the heart rate power spectrum at low frequency to the power at the respiratory frequency provided an even sharper discriminatory index between stable and critically ill patients. In addition it was noted that this ratio was markedly elevated in the setting of moderate to severe congestive heart failure, cardiac tamponade, and prior to the development of malignant ventricular arnythmias.

A low value for LFP/RFP (<2) which is sustained for greater than one hour or a value greater than or about 50 is associated with a clinical course characterized by cardiac arrest and/or profound hypotension. At times this ratio may be the only clinical indicator of cardiovascular instability. The LFP/RFP ratio provides a sensitive and specific index of cardiovascular instability and may provide a clinically important, continuous, non-invasive probe of cardiovascular stability.

In order to further examine the diagnostic value of the power spectrum of heart rate fluctuations and to overcome the difficulties with the prototype, a multipurpose microcomputer-based system, including data basing, instantaneous heart rate and respiratory

activity spectral monitor, was developed using a Hewlett Packard Series 200 Computer and Multiprogrammer as available from Hewlett-Packard. Advantages over the original design include: (1) error correcting routines which correct automatically for motion artifact and missed triggerings of the EKG, thus permitting a substantial increase (>30%) in available data; (2) automated trending of spectral densities along with the instanteous heart rate and respiratory activity time series; and (3) a data basing program which permits accurate temporal correlation of spectral densities with virtually every clinical intervention, routine ventilatory changes, hemodynamic, fluid monitoring and laboratory results. Software incorporating these advantages is included herein as Appendix A.

In a further improvement, programs and a data acquisition system and programs were developed for use with an IBM PC or compatible personal computer. This improvement is illustrated in Figs. 3 through 12.

In Fig. 3, a block diagram of apparatus according to the present invention is illustrated. In Fig. 3, a source of an ECG signal 2 and a source of an electroplythsmogram signal 3 are contained within a patient monitor 4. A patient monitor for use with the present invention may be the System 2 Infant Monitor available from ARVEE, Incorporated, Battle Creek, Michigan. Source 2 is connected to an ECG trigger 5 which is in turn connected to a personal computer 7. Source 3 is connected to an analog to digital interface 6. Interface 6 is connected to analog converter 8 which is connected in turn to a personal computer 7. Personal computer 7 receives input from and provides output to interface 6. Personal computer 7 is connected to a display 9.

Source 2 receives input from pregelled electrodes adhered to the chest wall and thigh of the

patient. Source senses respiratory activity through a pair of electrodes by the impedence method. Personal computer 7 and display 9 are available as an IBM PC and a compatible display available from IBM, Incorporated, Armonk, New York. Elements 5, 6 and 8 are described below.

In a data acquisition device according to the present invention, address buffers and address decoding, as illustrated in Fig. 4, receive input from a PC bus 10. Nodes 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 and 26 are respectively connected to address lines A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14 and A15 in PC bus 10. A first address buffer 100 has address inputs A0, A1, A2, A3, A4, A5, A6 and A7 which are respectively connected to nodes 11-18. Buffer 100 also has two gate inputs, 1G and 2G, which are connected to ground along with a ground output GND of buffer 100. A power supply input V_{CC} of buffer 100 is connected to a node 102 at a potential of +5 volts.

A second address buffer 110 has address inputs A8, A9, A10, A11, A12, A13, A14 and A15 which are respectively connected to nodes 19-26. Buffer 110 also has two gate inputs, 1G and 2G, which are connected by way of a node 111 to ground. A ground GND output of buffer 110 is also connected to a common potential. Buffer 110 has a power supply input V_{CC} which is connected to a node 112 at a potential of +5 volts.

A status buffer 120 has address inputs A16, A17, A18 and A19 which are respectively connected to nodes 27, 28, 29 and 30. Nodes 27-30 are respectively connected to an address enable line AEN, a reset line RES, an input/output read line IOR and an input/output write line IOW in PC bus 10. Buffer 120 has two gate inputs, 1G and 2G, which are connected by way of a node 121 to ground. A ground output GND of buffer 120 is

also connected to ground by way of node 121. A power supply input V_{CC} of buffer 120 is connected to a node 122 at a potential of +5 volts.

According to the present invention, a data acquisition system board which is both reliable and compatible with a personal computer (PC) bus, preferably adheres to the timing requirements and the loading requirements supplied by the PC bus. This means that all connections to the PC bus should be buffered so that the load provided at any input or output of the bus is equivalent to 1 LS TTL load and high speed CMOS integrated circuits are provided for this purpose.

Because there are multiple devices attached to the address bus, address buffers are provided. This is done by buffers 100 and 110. Parts used for buffers 100, 110 and 120 are normally gated, but the gate enables, 1G and 2G, are tied to ground so that the gates are always enabled. Some of the status lines on the PC bus are buffered by a chip 120, in particular: the reset line RES; the read and write lines IOR and IOW respectively, for the input/output (IO) channels; and the address enable AEN.

An address decoder according to the present invention, as illustrated in Fig. 4, includes a three to eight line decoder 130. Decoder 130 has three line inputs A, B and C which are respectively connected to outputs B2, B3 and B4 of buffer 100. Decoder 130 has gate inputs G2A and G2B which are respectively connected to outputs B5 and B6 of buffer 100. A power supply VCC input of decoder 130 is connected to a node 131 at a potential of +5 volts while a ground GND output of decoder 130 is connected to a common potential. Outputs Y0, Y1, Y2, Y3, Y4, Y5, Y6 and Y7 are connected to inputs of a NAND gate 140.

A NAND gate 151 has an input connected to each of outputs B8, B9 and B10 of buffer 110. An output B10

of buffer 110 is connected to an input of an inverter 152 which has an output connected to an input of NAND gate 151. Similarly, outputs B12, B13, B14 and B15 of buffer 110 are respectively connected to an input of each of inverters 153, 154, 155 and 156, each of which has an output connected to an input of NAND gate 151. NAND gate 151 has an output connected to an input of an inverter 157.

A NAND gate 158 has an input connected to an output of inverter 157 and has an output connected to an input of an inverter 159. An inverter 160 has an input connected to an output B7 of buffer 100 and has an output connected to an input of NAND gate 158. Likewise, an inverter 161 has an input connected to an output B16 of buffer 120 and has an output connected to an input of NAND 158. An output of inverter 159 is connected to a gate input G1 of decoder 130.

So that devices on the board are recognized at a particular IO channel address, address decoding is provided. In this particular case, a fixed address location, location hex 700 to 71F (a total of 32 channels), is used. The decoding of the fixed upper bytes in the address is provided by a combination of nine inverting gates, 152, 153, 154, 155, 156, 157, 159, 160 and 161, and NAND gates 151 and 158. These elements, in combination with decoder 140, provide chip enable signals which can be used to select one or another of the functional chips on our board. Each of the eight chip enable signals correspond to a block of four channels . For example, a chip select #0 from output to of decoder 130 corresponds to channels hex 700, 701, 702 and 703.

A logic network for driving a data buffer, as illustrated in Fig. 5, includes a NAND gate 171, an inverter 172 and a NAND gate 173. An output of inverter 172 is connected to a first input of NAND gate 173 while

an output of NAND gate 140 is connected by way of a node 174 to a second input of NAND 173 and to a first input of a NAND gate 175. A second input of NAND gate 175 is connected to an output of NAND gate 171.

In addition, a node 181 is connected to an output B0 of buffer 100. A node 182 is connected to an output B1 of buffer 100. Nodes 183 and 184 are respectively connected to output Y0 and output Y7 of decoder 130. Nodes 185 and 186 are respectively connected to an output of NAND gate 175 and an output of NAND gate 173. A node 187 is connected to an output B17 of buffer 120. A node 188 is connected an output B18 of buffer 120, to a first input of NAND gate 171 and to an input of inverter 172. A node 189 is connected to a second input of NAND 171 and to an output B19 of buffer 120.

Additional chips are used to provide logic which drives a data buffer connected to a data bus. The data bus is bidirectional in order to both transmit data to and from devices on the board. In order that this be accomplished, one must determine at any time whether or not data is either being read from or written to the board. This logic is supplied by NAND gate 171, NAND gate 173, AND gate 175 and inverter 172 which translates the read and write signals for the input/output (IO) channel into an output enable and a transmit enable for a data buffer. The apparatus of Fig. 4 may be used to properly interface a device to the PC bus 10.

As illustrated in Fig. 5, components according to the present invention for interfacing an ECG apparatus with a personal computer include a port expander 200. Port expander 200 has four sets of 8 nodes each, the four sets correspond to four ports A, B, C and D. The outputs for port A are A0, A1, A2, A3, A4, A5, A6 and A7. The inputs corresponding to port B are B0, B1, B2, B3, B4, B5, B6 and B7. Outputs corresponding to port C are C0, C1, C2, C3, C4, C5, C6

and C7. A set of outputs corresponding to port D includes D0, D1, D2, D3, D4, D5, D6 and D7. Expander 200 has a chip select input CS connected to node 184. Expander 200 also has a read input RD and a write input WR respectively connected to nodes 188 and 189. Expander 200 has two address inputs, AD0 and AD1 which are respectively connected to nodes 181 and 182. A reset RES input of expander 200 is connected to node 187. Inputs A0, A1, A2, A3, A4, A5, A6, A7 are respectively connected to nodes 291, 292, 293, 294, 295, 296, 297 and 298. Outputs D0-D7 are respectively connected to nodes 208, 207, 206, 205, 204, 203, 202 and 201 which define a data bus. A power supply input V_{CC} of expander 200 is connected to a node 209 at a potential of +5 volts. A ground GND output of expander 200 is connected to a common potential.

Port expander 200 is used to overcome the low speed of the data bus on both A/D converter 260 and a digital analog converter. This permits slowing down the read and write signals inasmuch as they may be provided artifically on port C of expander 200 or as chip select signals from address decoder 130. Port C of expander 200 is a bit addressable register which allows one to individually select or deselect bits without affecting any of the other bits. This is accomplished by sending a one byte command to expander 200. Because expander 200 is given the control function, the address of expander 200 is the highest address in the set of channels. In other words, expander 200 occupies IO channels hex 71C to hex 71F. The ports A, B and C on expander 200 are addresses 71C, 71D and 71E, respectively, and the control register internal for expander is at input/output I/O channel 71F.

A timer 220 according to the present invention has two address inputs, AD0 and AD1 respectively connected to nodes 181 and 182. Timer 220 also has a

read input RD connected to node 188, a write input WR connected to node 189 and a chip select input CS connected to node 184. A first gate input GO is connected to the CO of expander 200 while a second gate input G1 and a third gate input G2 are both connected by way of a node 223 to output C1 of expander 200. Timer 220 has three clock inputs CLK0, CLK1 and CLK2, of which CLK1 is connected by way of node 222 to an output OUT0 of timer 220 and input CLK2 is connected to an output OUT1 of timer 221 by way of a node 31. An interrupt request line IRQ4 within PC bus 10 is also connected to node 31.

An output OUT2 is connected to a non-inverting input of an operational amplifier 224, an inverting input and a output of which are connected to a node 400.

A power supply input V_{CC} of timer 220 is connected to a node 221 which at a potential of +5 volts.

Timer 221 has seven outputs D0, D1, D2, D3, D4, D5, D6 and D7 which are respectively connected to nodes 208, 207, 206, 205, 204, 203, 202 and 201. A ground output of timer 220 is connected to a common potential.

Timer 220 includes three 16 bit timers which are addressed at hex locations 704, 705, 706, and 707. In other words, they are provided by chip select 1. The three clocks on timer 220 are connected in series which effectively converts it into a 48 bit counter. However, in the operation of the program, some of the bits in this counter are thrown away because the reset values are less than 65,536. The three clock registers are used in the following way. Counter 0, corresponding to input CLK 0, counts an onboard time base to be discussed later and provides an output which gives the minimum resolution of the heart rate counting. In other words,

it provides the counter time base for measuring the heart rate. Counter #1, corresponding to input CLK 1, counts the heart rate counter time base and provides as an output an interrupt at IRQ4. This signal drives the sampling of the respiratory signal at a constant frequency, and is also used to measure interbeat intervals. In the standard data collecting mode, where one is interested in measuring the respiratory signal at 4 hertz intervals, this means that the counter 0 is set to generate output pulses at 11 microsec. intervals and that these pulses are in turn counted by counter 1 to generate 4 hertz pulses which are used to drive data acquisition from the respiratory signal. The last counter register, counter #2, corresponding to input CLK2, is used to count the number of respiratory sampling pulses which have been supplied. This functions as an overflow counter and always has the reset value of 65,536. Thus the counter measuring interbeat intervals effectively overflows only every 65,536 respiratory sampling times, which is far in excess of what would be required to recover dropped beats which occur because the heart rate is not adequately detected.

A counter 240 has an input 1A connected to a clock line PC CLK in PC bus 10 by way of a node 32. Counter 240 has a first output 1QA connected to the CLK0 input of timer 220. Counter 240 has a secnd output 1QB and has a third output 1QC. A clear input CLR1 of counter 240 and a ground output GND of timer 240 are connected to a common potential by way of a node 242.

A data output buffer 280 has an output enable input OE connected to node 185 and has a tranfer enable input TE connected to a node 186. Eight data inputs, A0, A1, A2, A3, A4, A5, A6 and A7, of buffer 280 are respectively connected to nodes 208, 207, 206, 205, 204, 203, 202 and 201. A power supply V_{CC} input of buffer

280 is connected to a source of potential at +5 volts. A ground GND output of buffer 280 is connected to a common potential. Outputs B0, B1, B2, B3, B4, B5, B6 and B7 of buffer 280 are respectively connected to data lines in PC bus 10 by way of nodes 33, 34, 35, 36, 37, 38, 39 and 40.

The time base for this clock system is provided by counter 240. Timer 220 counts only at a rate of 2.6 MHz megahertz which is exceeded by the IBM PC bus clock of 4.77 megahertz. The IBM PC bus clock is divided by 2 using counter 240 and the result used to provide a time base at 2.38 megahertz for timer 220. The 4.77 megahertz clock is also divided by 8 to provide a 596 kilohertz clock which is used to drive an analog to digital (A/D) converter. A/D converter 260 uses this clock signal in order to properly execute the successive approximation scheme to convert analog inputs into digital outputs.

A/D converter 260 has an output enable input OE connected to output C4 of expander 200. A/D converter 260 also has three inputs A, B and C which are respectively connected to outputs C5, C6 and C7 of expander 200. A clock input CLK of A/D converter 260 is connected to the 1QC output of counter 240. An address latch enable ALE and a start input STR of A/D converter 260 are connected to a node 261. A power supply V_{CC} input and a reference voltage $+V_{REF}$ input of A/D converter 260 are connected to a node 262 at a potential of +5 volts. A reference voltage $-V_{REF}$ output and a ground GND output of A/D. converter 260 are connected to a common potential by way of a node 263. A/D converter 260 has seven outputs D0, D1, D2, D3, D4, D5, D6 and D7 which are respectively connected to inputs B0, B1, B2, B3, B4, B5, B6 and B7 of expander 200. In addition, A/D converter 260 has an end of count EOC output connected to a first input of the NAND gate 264, an output of

which is connected to an input of an inverter 265. A second input of NAND gate 264 is connected to an output of an inverter 266 which has an input connected to node 187. An output of inverter 265 is connected to node 261.

A/D converter 260 has a signal input IN connected to a node 267. An output of an operational amplifier 268 is connected to node 267 and to a first lead of a resistor 269. A second lead of resistor 269 is connected to a first lead of resistor 270, a second lead of which is connected to a source of potential at -5 volts. The first end of resistor 270 is also connected to an inverting input of amplifier 268 and to a first end of a resistor 271. A non-inverting input of amplifier 268 is tied to ground. A second end of resistor 271 is connected to a node 272 which provides an analog signal input ANA IN for the apparatus according to the present invention.

A/D converter 260 is connected to port B of port expander 200. This A/D has built into it its own 8 channel analog multiplexer which allows the selection of one of eight analog signals to be converted. The channel select corresponding to inputs A. B and C of converter 260 is connected to port C on bytes 5, 6 and 7.

Because A/D converter 260 operates from 0 to 5 volts, analog input at input IN should be in the range of 0 to 5 volts or an input buffer should be supplied to alter this input range. However, in keeping with general practices for safety and isolation, input IN should always be provided with an analog buffer to provide isolation for both the computer and the instrument being monitored. As illustrated, the input buffer is provided by operational amplifier 268. This amplifier converts a bipolar analog input of plus or minus 5 volts to a single unipolar input of 0 to 5 volts

at input IN. This analog input is used to monitor the respiration.

A/D converter 260 is set up in a free running mode such that it continuously does conversions on the analog signal. The end-of-conversion pulse at output EOC is used to generate a start pulse for the A/D so that as soon as an end of conversion occurs it a new conversion is started. This is the reason for the two gates connected between end of conversion output EOC and the start input STR. In order to prevent latchup of the device on power up, the reset line at node 187 is also used to generate a start pulse. This means that the device will always function even after being powered up. Also, in order to update A/D converter 260 as frequently as possible, the address latch enable ALE, which is used to latch in the address value for the channel to be monitored, is re-latched at every start pulse.

As illustrated in Fig. 6, digital analog (D/A) converter 300 has inputs D0, D1, D2, D3, D4, D5, D6 and D7 which are respectively connected to nodes 298, 297, 296, 295, 294, 293, 292 and 291 as illustrated in Fig. 5. Converter 300 has a write WR input connected to node 183 and has a feedback input RFB. Converter 300 also has a power supply V_{CC} input, a reference voltage V_{REF} input and an input latch enable input ILE all of which are connected to a source of potential at +5 volts by way of a node 301. Converter 300 has an analog ground AGND and a digital ground output DGND, both of which are connected by way of a node 302 to a common potential.

Converter 300 has a first output OUT1 and a second output OUT2 which are respectively connected to an inverting and a non-inverting input of an operational amplifier 303. The non-inverting input of amplifier 303 is also connected to a common potential by way of a node 305. Amplifier 303 has an input connected to a node 306

at a potential of +12 volts and an input connected to a node 307 at a potential of -12 volts. An output of amplifier 303 is connected to a node 308 which is connected to the RFB input of converter 300 and to a first end of a variable resistor 309. A second lead of variable resistor 309 is connected to a first lead of a variable resistor 310, a second lead of which is connected to a node 311 at a potential of +5 volts. The second lead of resistor 309 is also connected to an inverting input of operational amplifier 312 and to a first lead of a resistor 313. A non-inverting input of amplifier 312 is connected to ground. A second lead of resistor 313 is connected to an output of amplifier 312 and to a node 391 which serves as an analog output for the apparatus according to the present invention.

Port A of expander which is at location 71C, is attached to a D/A converter data bus which, includes nodes 291-298. The write latch signal for the D/A converter is provided by chip select #0. In other words, any dummy byte written to any of the addresses 700, 701, 702 or 703 hex will cause a write pulse to be sent to D/A converter 300, thereby latching the data on port A of expander 200 into the D/A converter 300 and allowing an analog signal to be generated corresponding to the digital input. The output of D/A converter 300 chip is in the form of differential currents generated at outputs OUT 1 and OUT 2. A system having two operational amplifiers is employed to convert these currents to a voltage. Amplifier 303 is a differential current to voltage converter which provides a signal from 0 to 5 volts. Amplifier 312 converts the signal to a bipolar plus or minus 5 volt signal. Feedback control for the current to voltage converter is provided in D/A converter 300 through input RFB so that in actuality three connections are made from the D/A chip to the first operational amplifier. Because the D/A converter

is an 8 bit device, this provides 256 voltage levels which are linearly distributed between plus and minus 5 volts. This D/A output may be used to generate calibrating signals or other control signals.

As illustrated in Fig. 7, a source of an ECG signal is connected by way of a node 400 to a non-inverting input of an operational amplifier 401 in an ECG trigger 60. An input of amplifier 401 is connected to a node 402 at a potential of plus 12 volts. An inverting input of amplifier 401 is connected to an output of amplifier 401 and to a non-inverting input of an operational amplifier 406. A first lead of each of resistors 403a, 403b, 403c, 403d, 403e, 403f, 403g, 403h and 403i is connected to the output of amplifier 401 while the second lead of resistor 403i is permanently connected and a second lead of one other of resistors 403a through h is connected to a node 410 by a jumper. A first lead of capacitor 404 is connected to node 410 while a second lead of capacitor 404 is connected to a node 405 at a potential of minus 12 volts. An inverting input of amplifier 406 is connected to a cathode of a diode 407, an anode of which is connected to an output of amplifier 406. The cathode of diode 407 is also connected to a first lead of capacitor 408 and a first lead of each of resistors 410a, 410b, 410c, 410d and 410e, the second lead of resistor 410e is permanently connected and the second lead of one other of which is connected to a node 410 (not shown) by a jumper 411g (not shown). A non-inverting input of an operational amplifier 412 is also connected to the cathode of diode 407 while an inverting input of amplifier 412 is connected to the output of amplifier 406. An input of amplifier 412 is connected to a node 413 at a potential of minus 12 volts. A first lead of resistor 414 is connected to the output of amplifier 412 while a second lead of resistor 414 is connected to a

cathode of a diode 415 an anode of which is connected to ground. The cathode of diode 415 is also connected to an input of a Schmitt trigger 416 an output of which is connected to a line designated IRQ 3 in PC bus 10 by way of a node 491.

ECG trigger 60 has an input buffer consisting of a non-inverting buffer of an amplifier 401 which isolates the ECG signal from the rest of the board. As illustrated in Fig. 5, the EKG trigger functions in the following manner. The R wave, which is larger than any other signal in the ECG, causes capacitor 408 to charge up to a certain value corresponding to the peak of the R wave. Any values beneath the peak of the R wave will be rejected by amplifier 403 so that no output occurs. Between R waves, the voltage on capacitor 405 decays slowly with a rate given by the RC time constant of capacitor 405 and the resistance across elements 410a-f. The voltage on the capacitor is sent to the inverting input on amplifier 403 and is used as a threshold for the R wave of the EKG. Therefore, as the electrocardiogram is being passed to the non-inverting input of amplifier 406, the only time that the operational amplifier has a positive output is when the EKG signal is larger than the voltage on capacitor 405. Whenever this occurs, capacitor 408 is immediately charged up to the value at the EKG input. In other words, the voltage on capacitor 408 is a sort of envelope on the top of the electrocardiogram, although its decay rate is limited by the RC time constant. Diode 407 insures that the envelope function which is provided by capacitor 408 is the upper envelope and not the lower envelope. The lower envelope is provided by reversing the polarity of diode 407.

The RC network of capacitor 405 and resistors 403a-i provides a low pass filtered ECG. The voltage on capacitor 405 is the baseline for the ECG, which may

vary. The array of jumper selected resistors 410a-e allows variation of the time constant of the RC network containing resistors 406a-e and capacitor 408. Thus, this latter network which monitors the ECG envelope is referenced to the ECG baseline present on capacitor 404 permitting accurate tracking of the envelope and therefore better R wave detection. As a further improvement, the jumpers may be replaced with analog switches controlled by the personal computer in order to give the computer control of RC time constant selection.

An output from ECG trigger 60 is generated by connecting amplifier 412 in parallel with peak detector amplifier 406 so that the inputs are reversed. The result is that the output polarity is inverted. Because the amplifiers 401, 406 and 412 are operating from a plus 12 volts to minus 12 volts supply, but the logic levels on the board are only from 0-5 volts, resistor 414 and a diode 415 are used to clamp the output value of the amplifier 412 between 0 and 12 volts. This signal is then passed to a Schmitt trigger 416, which is a single conditioning device. The output of this signal conditioner is finally provided to PC bus 10 in order to drive interrupts at interrupt request 3 (IRQ3) indicating the currents of an R wave. ECG trigger 60 may be modified to allow selection of various decay rates for the envelope and also to provide a floating threshold for the 0 point of the EKG. The ECG triggers if the R wave passes above 0 volts. However, it can be imagined that sometimes the baseline will drift far enough below 0 volts that the R wave does not cross 0 volts and in such a case this trigger would never detect the R wave. This is corrected by connecting the second leads of the charging capacitor 408 and on the selected discharging resistor of 406a-f may be connected to a low pass filter consisting of a capacitor 405 and a selected one of resistors 403a-f (to choose various discharge

rates) which low pass filters the electrocardiograms and essentially selects out the baseline. This means that instead of measuring the R wave with respect to 0 volts, the R wave may be measured with respect to the floating baseline of the electrocardiogram. The jumper selected resistor selects an RC time constant much greater than the RR interval. So long as the baseline does not drift faster than one R wave in approximately 10 heart beats, this means that this trigger will successfully detect all R waves. Selecting one of resistors 410a-f allows variation of the RC time constant of elements 408 and 410a-f.

As illustrated in Fig. 8, in a portable calibrator 70 according to the present invention, an operational amplifier 500 has a non-inverting input connected to a first lead of each of resistors 501, 502 and 503. A second lead of resistor 501 is connected by way of a node 503a to a positive voltage source while a second lead of resistor 502 is connected by way of a node 504 to a negative voltage source. An inverting input of amplifier 500 is connected to a first lead of a capacitor 505, a second lead of which is connected by way of a node 506 to a negative voltage source. The inverting input of amplifier 505 is also connected to a first lead of a variable resistor 507 and to a first lead of a resistor 508 a second lead of which is connected to an output of amplifier 500. The output of amplifier 500 is also connected to a second lead of resistor 503. Amplifier 500 has an input connected by way of a node 509 to a positive voltage source and by way of a node 510 to a negative voltage source.

A second lead of resistor 507 is connected to a non-inverting input of an amplifier 511, an inverting input of which is connected to an output of amplifier 511 by way of a node 591 which provides an output port for a simulated respiratory frequency.

A first lead of a resistor 512 is connected to node 591 while a second lead of resistor 512 is connected to a first lead of a resistor 513 and to a first lead of a capacitor 514, a second lead of which is connected by way of a node 515 to a negative voltage source. A second lead of resistor 513 is connected to an output of an operational amplifier 514 and to an inverting input of amplifier 515 is connected to a first lead of a resistor 516, to a first lead of a capacitor 517 and to an inverting input of an operational amplifier 518. The second lead of capacitor 517 is connected by way of a node 519 to a negative voltage source. A non-inverting input of amplifier 518 is connected to a first lead of each of resistors 520, 521 and 522. A second lead of resistor 520 is connected by way of a node 523 to a positive voltage source while a second lead of resistor 521 is connected by way of a node 524 to a negative voltage source. A second lead of resistor 522 is connected to an output of amplifier 518 and to a second lead of resistor 516.

An inverting input of an operational amplifier 525 is connected to the first lead of resistor 513 and to a first lead of a variable resistor 526. A non-inverting input of amplifier 525 is connected to a first lead of each of resistors 527, 528 and 529. A second lead of resistor 527 is connected to a node 530 at a positive potential while a second lead of resistor 528 is connected by way of a node 531 to a negative voltage source. A second lead of resistor 529 is connected to a second lead of resistor 526 and to an output of amplifier 525 at a node 592 which provides a square wave output simulating a modulated heart rate pulse. A first lead of a capacitor 532 is connected to node 592 while a second lead of capacitor 532 is connected by way of a node 593 to a first lead of a resistor 533, a second lead of which is connected to

ground. Node 593 provides an output port for a spike output simulating the R wave of an EKG.

The source of positive potential for the portable calibrator 70 may be at a voltage between about plus 5 and about plus 18 volts. Similarly, the negative voltage source for portable calibrator 70 may be at a potential of about minus 18 volts to about minus 5 volts.

Portable calibrator 70 provides test signal for the heart rate spectral analysis hardware which, although not of a truly calibrated nature, does allow one to evaluate whether or not the software and hardware is functional. Each of the output signals provided is a triangle wave which represents the respiration and a frequency modulated pulse train representing the heart rate. The modulation of the heart rate is provided at two frequencies which simulate a respiratory modulation and also a low frequency modulation.

The basic circuit of calibrator 70 for providing each pulse train consists of an oscillator having one operational amplifier as typified by the respiratory frequency modulator. A charging capacitor 505 and a variable resistor 507, provide an RC circuit which is charged by the output of the amplifier 500. It is also discharged by the amplifier 500 when the output of the amplifier 500 is low. Progressive cycles of the oscillator consist of charging and discharging the capacitor at the rate prescribed by the RC circuit. The reference level which determines whether or not one is discharging or charging is provided at the non-inverting input of the amplifier 500.

Suppose, for example, that capacitor 505 begins as being completely discharged, then the voltage at the inverting input for the operational amplifier 500 is low. The output of the operational amplifier 500 is therefore high and this means that the input at the

non-inverting input is 2/3 the voltage between the negative voltage source V and the positive voltage source V+. Thus the capacitor 505 begins to charge. When the capacitor voltage exceeds the threshold at the non-inverting input of the operational amplifier 500, the output of operational amplifier 500 changes sign and capacitor 505 begins to discharge. However, when the output of the amplifier 500 changes to the negative side, then the threshold voltage at the non-inverting input is changed and now becomes only 1/3 the way from the negative voltage source to the positive voltage source. This means that the voltage on the charging capacitor 505 varies between 1/3 and 2/3 the difference between the negative and the positive voltage source. This determines the range of output on capacitor 505. The voltage at capacitor 505 is buffered by a non-inverting buffer 511 and this provides the respiratory signal at node 591.

An identical oscillator is used to provide low frequency modulation. The difference in the two frequencies is obtained by adjusting the respective variable resistors, 505 and 517,which set the RC time constants. The outputs of these two modulators are fed by resistors 512 and 513 into the charging capacitor 514 for the heart rate.

The heart rate oscillator is similar in design and consists of variable resistor 526 and capacitor 532 which charges and discharges in cycles with the range of voltages on the capacitor ranging between 1/3 the distance from the negative voltage source to the positive voltage source to 2/3 the voltage between the negative voltage source and the positive voltage source. Resistors 512 and 513, which connect the outputs of the low frequency and respiratory frequency modulators to the heart rate modulator, allow a small amount of current to flow into charging capacitor 514 of

the heart rate modulator. This alters the charging rate of capacitor 514 and thereby affects the rate at which the heart rate oscillator oscillates. For example, on a positive cycle of the respiratory frequency modulator, the heart rate capacitor is charging more rapidly towards the plus side because more current is being supplied on the plus side of the cycle. Finally, the output of the heart rate modulator is sent through an RC filter comprising capacitor 532 and resistor 533 which converts the square wave output of the heart rate modulator into a spike output which may be sent to an R wave detector. Notice that the spike output includes both positive and negative spikes so that an R detector which depends on a high frequency filtering function may be discharging at twice the heart rate, inasmuch as it may trigger on both positive and negative spikes.

As illustrated by a block diagram in Figs. 9A and 9B, a block diagram may be constructed for the main program (designated SYNCTS19) and for sub-routine modules (SYNC7s, GWINDOW3, and FGRAPH8). This block diagram may be used in order to better interpret a complete program for heart rate fluctuation spectral analysis useful on an IBM personal computer, as illustrated in Appendix B. Although programs are provided for a Hewlett-Packard and an IBM computer herein, the software and other aspects of the present invention may be readily modified for use with other mini- and micro-computers.

In the program of Appendix B, is a routine for removing artifacts from a detected heart rate provided for by an electrocardiograph machine. This program computes histograms from the heart rate data in order to generate a tachometer waveform. The most common rate on the histogram is selected as the correct rate and other rates are interpreted in light of it. Specifically, in order to correct for a spurious extra trigger, where a

first and a second beat are close together while a third beat is spaced at an abnormally long interval, the second beat is discarded if the first beat to second beat interval is less than a predetermined value. The resulting interval between the first and the third beats is divided by an integer in order to provide a more normal intrabeat interval. Where a trigger has been missed, so that a first and a second beat are separated by an interval which is approximately a multiple of a normal intrabeat interval, the intrabeat interval is divided by that multiple, most commonly two, in order to provide a more correct interval length. If the slewing rate of the heartbeat samples is outside of an acceptable range of slewing rates determined as a function of a mean variance, and the problem cannot be identified as a missed trigger or as a spurious extra trigger, or if the three previous intervals have been corrected, a determined mean interval, against which all other intervals are judged, is substituted for the inappropriate interval.

The slew rate is calculated on a moving average of the heart rate waveform and corrects for triggers that fall within the parameters of 0.05 Hz (3 beats/min.) per beat and five times the maximum slew. This artifact-correcting routine never slews more than 10 percent of the heart rate waveform.

Within the software of Appendix A is a graphic routine for trending heart rate fluctuation spectral data. The parameters of LFP, RFP, LFP/RFP ratio and heart rate are plotted on a graph over time to show trends in the four parameters. These trends may then be studied in order to examine the effects of various clinical interventions. Values for the parameters heart rate, LFP/RFP ratio, LFP and RFP are stored and may be called up at any point in time through a graphing routine in order to provide a graphic depiction of the

course of a patient's condition. This sort of graphic depiction is illustrated for a stable patient in Fig. 10 and for an unstable patient in Fig. 11.

Also present in the program of Appendix B, a routine is provided for the segmentation of data and subsequent reanalysis. In this routine, data from the analog to digital converter 260 is collected continuously into a buffer and is dumped to a disk in blocks of 1,024 numbers (2,048 bytes equals 1,024 words and each block is referred to as a record or EPOCH). The time of heartbeat occurrence as measured by the signal provided by outputs OUT1 and OUT2 of timer 220 are collected continuously into two buffers (hb buffer 1 and hb buffer 2). These times are dumped to the disk in blocks of 1,024 pairs of numbers (1,024 from each buffer which equals 2,048 bytes or 1,024 words each). Because the heart rate is less than the sample rate of A/D converter 260 as required by signal processing, there are fewer heartbeat disk dumps.

In order to properly analyze data, the A/D and heartbeat data must correspond to the same time interval for the purpose of doing correlations. The correspondence may be determined from (1) the record number in a A/D file and (2) the absolute of the times stored in the heartbeat file (time differences used for intrabeat intervals). The instantaneous heart rate signal is generated backwards in time from the heartbeat corresponding to the last A/D sample in the record of interest. This means that if the heart rate signal is analyzed on a frequency scale not corresponding to the respiration data (e.g. respiration sample at 16 Hz but a heart rate analysis at 0 to 4 Hz) then the heart rate waveform extends backwards in time beyond the beginning of the present A/D record. This means that the heart rate waveform overlaps the heart rate waveform corresponding to the previous A/D records.

Overlapping permits lower frequency analysis than would be possible if only data corresponding to the present record were used (as in the prototype apparatus). Also, overlapping leads to the smoothing of parameters and to the subsequent reduction of fluctuating artifacts. In addition, it becomes less critical at what point analysis begins.

A calibration program providing a software driven calibrator, which may provide more realistic spectral data than the portable calibrator of Fig. 8, is contained within the program of Appendix A for a Hewlett-Packard micro-computer. Appendix C is a program which, although not tested, is believed to provide the same sort of software-driven calibration for an IBM personal computer through the data acquisition system of Figs. 4 through 7.

In general, outputs OUT0 and OUT1 of timer 220 in Fig. 5 generate a time base used via interrupt request line IRQ4 to clock data from a buffer to D/A converter 300. This buffer contains a respiratory waveform which may be a sign wave or any selected waveform as obtained by changing the contents of the buffer. Output OUT2 of timer 220 generates a heartbeat pulse as its output. In order to work properly, this pulse must be returned to the ECG trigger through node 400 or directly to interrupt request line IRQ3. If the latter course is chosen, however, node 491 must be disconnected from the output of Schmitt trigger 416. By returning the pulse to the ECG trigger, the computer is informed that the timer is through counting the present RR interval and needs a new interval to be loaded into a timer register of timer 220.

Through the use of the apparatus according to the present invention, a display of instantaneous heart rate as provided by an electrocardiograph machine, and as illustrated in Fig. 12, may be converted into an

instantaneous heart rate fluctuation spectrum as illustrated in Fig. 14. A typical spectrum for a stable patient is illustrated in Fig. 14 while a typical spectrum for an unstable patient is illustrated in Fig. 15.

Example I and Example II relate respectively to diagnosis and to treatment employing the present invention.

Parts suitable for use in construction of the apparatus as illustrated in Figs. 4 through 9 may include those as listed in Tables I, II, III and IV.

TABLE I

Element No.	Part No.	Manufacturer, Location
100, 110, 120	74HC244	National Semiconductor Santa Clara, California
130	74HC138	National Semiconductor Santa Clara, California
140, 151, 158	74HC30	National Semiconductor Santa Clara, California
152, 153, 154 155, 156, 157 159, 160, 161 172, 265, 266	74HC04	National Semiconductor Santa Clara, California
171, 173, 185 264	74HC00	National Semiconductor Santa Clara, California
200	8255A-5	Intel Corporation Santa Clara, California
220	8253-5	Intel Corporation Santa Clara, California
224		
240	74HC393	National Semiconductor Santa Clara, California
260	ADC0808	National Semiconductor Santa Clara, California

268, 303, 312 401, 406, 412 500, 511, 515 518, 525	LM324AN	National Semiconductor Santa Clara, California
280	8286	Intel Corporation Santa Clara, California
300	DAC0830	National Semiconductor Santa Clara, California
416	74HC14	National Semiconductor Santa Clara, California

TABLE II

Diodes

Element	Part No.
407, 415	IN4148

TABLE III

Resistors

Element No.	Value (in ohms)
403i, 410	2.2k
269	5k
270, 271, 409	10k
403h	15k
403g	27k
403f	56k
313	82k
309, 310, 501, 502, 503, 520, 521, 522, 527, 528, 529, 533, 403e	100k (variable)
403d, 410d	220k
403c, 410e	560k
508, 516, 526, 403b, 410b	1M(variable)
512, 513, 403a, 410a	2.2M

TABLE IV

Capacitors

Element No.	Value (in microfarads)
405	2.2
404, 505, 517	10
532	0.1
514	1

EXAMPLE 1

Heart rate spectral analysis was applied to the study of congestive heart failure in infants and children. Congestive heart failure is characterized by a marked alteration in cardiovascular regulation. However, many cardiovascular functions which are normally monitored in cardiac intensive care units (such as: mean heart rate; arterial blood pressure; arterial blood gases; left arterial pressure and right arterial pressure; right atrial, left atrial and pulmonary artery oxygen saturations; the peripheral pulses; peripheral perfusion; and cardiac output) may not clearly indicate a critically unstable cardiovascular condition. The usually-monitored cardiovascular function parameters may be within a normal range immediately before a major cardiovascular crisis, such as hypotension or cardiac arrest, inasmuch as the cardiovascular regulatory system maintains these parameters within a normal range up to the point of system failure.

Twenty-nine infants and children were studied in a cardiac intensive unit. Of the twenty-nine patients, twenty-six have undergone a cardiac surgical

procedure. The patients were studied for a minimum of three hours and a maximum of twenty-seven hours, with a mean study time of eight hours. EKG for cases were recorded and analyzed continuously in real time during the study time.

Data for a particular patient was analyzed only if the patient was in sinus rhythym. The patient's clinical course during the period of study was reviewed and, in particular, major events such as cardiac arrest, hemorrhage and profound hypotension were correlated with spectral analysis data. Administration of medication and the mode of ventilation were noted.

Real time heart rate spectral analysis was performed on a dedicated personal computer using a 6809E Motorola Microprocessor-Based System. A data acquisition system interfaced the computer with a patient monitor, available from Hewlett-Packard, Palo Alto, California, as Model No. 78341.

The heart rate power spectrum was calculated in continuous 256 second data epochs. A QRS synchronization pulse from the patient monitor was used to determine an RR interval sequence. An instantaneous heart rate signal was computed from RR interval sequence and the magnitude of the signal was set to the reciprocal of the current interbeat interval. The instantaneous heart rate signal was sampled at 4 Hz and the mean heart rate was substracted from the resulting one thousand twenty-four point time series. A power spectrum was computed by squaring the absolute value of a Fast Fourier Transform of the one thousand twenty-four point time series. Values for low frequency power (LFP) were computed by integrating the spectrum of between 0.04 and 0.1 Hz. Respiratory frequency power (RFP) was computed by integrating the heart rate power spectrum over a 0.2 Hz-wide band centered at the mean respiratory frequency.

Hard copies of the heart rate time series and power spectrum were printed for each 256 second epochs. Trend graphics for the LFP, the RFP, LFP/RFP ratio, mean heart rate and respiratory rate (hereinafter referred to as the study parameters) were constructed by manually entering data in data files and analyzing the entered data by means of a computer.

Mean values for the study parameters were calculated for each period of study. The Mann-Whitney Rank Sum Test was used to determine statistically significant changes in the study parameters in individual patients and to determine differences among groups of patients. When patients were segregated into more than two groups, the Kruskal-Wallis Test, multiple comparison test, and Tukey's HSD were employed to determine statistical significance. P values of less than 0.05 were considered significant.

It was found that during each three to twenty-four hour period of study the study parameters for a given patient, the LFP, the RFP and the LFP/RFP ratio (hereinafter referred to as the spectral parameters) remain fairly stable.

Based upon the results of this study, the patients were retrospectively divided into three groups. Group I included seventeen stable patients whose median age was one month. The patients in Group I were without major post-operative complications and did not need prolonged inotropic support. The eight patients in Group II suffered cardiac arrest and died. The median age for the members of Group II was one month. In Group III, there was a total of four patients each of whom was critically ill at the time of the study but later recovered. Median age of the members of Group III was one month. Of the four members of Group III, one required re-operation, one had intermittent hypotensive episodes, and two had cardiac arrests from

which they were successfully resuscitated.

In order to separate all twenty-nine patients into a group of stable patients (Group A) and a group of critical patients (Group B), data from each patient in Group III was divided into the data collected during the stable period (which applied to three patients) and the data collected during the preceding critical period (which applied to four patients). When handled in this way, Group A included data for twenty patients and Group B included data for twelve patients. Typical heartrate fluctuation power spectra for Group A and B are respectively illustrated in Figs. 16 and 17.

In addition, studies were performed on three patients who had isolated coarctation of the aorta at three points in time: upon admission for congestive heart failure; during treatment; during post-operative period; and prior to discharge from an intensive care unit. An attempt was made to identify changes in cardiovascular regulatory function of each of these stages.

Patient profiles for Groups I, II and III are respectively provided in Tables V, VI and VII. These profiles include age, diagnosis and operation.

TABLE V

PATIENT PROFILE; STABLE POST-OP N=17

AGE	NO.	DIAGNOSIS	(NO.)	OPERATION
<30 DAYS	9	TGA,IVS	(3)	ARTERIAL SWITCH
		TGA,VSD,PS	(1)	L-BTS
		HLHS	(1)	STAGE 1 REPAIR
		SV	(1)	L-BTS
		SEV. COAO	(3)	SUBCL.FLAP ANGIO.

1-12 MO.	5	TGA,IVS	(1)	ARTERIAL SWITCH
		TGA,VSD,PS	(1)	BTS
		MULT.VSD'S	(1)	VSD PATCH REPAIR
		SUPRA-V. PS	(1)	PA PATCH PLASTY
		DCRV,VSD,COAO	(1)	VSD REPAIR, ANOM. B RESECTion
1-10 YRS.	2	PS	(1)	PULM. VALVOTOMY
		TOF	(1)	TOF REPAIR
>10 YRS.	1	AR,MR		AVR,MVR

TABLE VI

PATIENT PROFILE; CRITICAL, DIED N=8

AGE	NO.	DIAGNOSIS	(NO.)	OPERATION
<30 DAYS	4	HLHS	(3)	NORWOOD PROCEDURE
		SV W/IAA	(1)	GORE-TEX GRAFT
1-12 MO.	3	HLHS	(1)	Fontan operation
		DORV,TAPVC, CCAVC	(1)	TAPVC REPAIR, SYS. PULM. SHUNT
		HLHS	(1)	NON-OPERATIVE
6 1/2 YRS.	1	T OF S/P REPAIR W/ CHRONIC SEV. CARDIOMYOPATHY, S/P ARREST		NON-OPERATIVE

TABLE VII

PATIENT PROFILE: CRITICAL, RECOVERED N=4

AGE	NO.	DIAGNOSIS	(NO.)	OPERATION
<30 DAYS	3	HLHS,COAO	(1)	NORWOOD PROCEDURE
		HLHS	(2)	NORWOOD PROCEDURE
14 YRS.	1	ACUTE MYOCARDITIS, S/P ARREST		NON-OPERATIVE

In Tables V, VI and VII: TGA is Transposition of the Great Arteries; IVS is Ventricular Septal Defect; PS is Pulmonic Stenosis; HLHS is Hypoplastic Left Heart Syndrome; SV is Single Ventricle; SEV. is severe; COAO is Coarctation of the Aorta; MULT is multiple; VSD is Ventricular Septal Defect; Supra-V. is Supravalulvar; DCRV is Double Chamber Right Ventricle; TOF is Tetralogy of Fallot; AR is Aortic Regurgitation; MR is Mitral Regurgitation; W/IAA is with Interrupted Aortic Arch; DORV is Double Outlet Right Ventricle; TAPVC is Total Anomalous Pulmonary Venous Connections; CCAVC is Complete Common Atrial Ventricular Canal; S/P is Status Post; L is Left; BTS is Blailock Taussig Shunt; PA is Pulmonary Artery; ANOM. is Anomalous; B is muscle Bundle; PULM is Pulmonary; and SYS is Systemic.

Statistically significant differences were observed in the heart rates spectral parameters between the groups of patients as well as among the individual patients. However, the mean heart rate alone did not distinguish stable from critically ill patients. Both the LFP and the LFP/RFP ratio discriminated between the Group A (stable) patients and the Group B (critical) patients. The LFP/RFP ratio grew out of a statistically significant (p less than symbol 0.00001) discrimination

between stable and critical patients. Table VIII presents means of study parameters.

TABLE VIII

MEANS OF STUDY PARAMETERS

GROUP A, STABLE

PARAMETER (BEATS/MIN.)	MEAN	STD. DEV.	STD. ERROR OF MEAN	99% CONFIDENCE LOWER	99% CONFIDENCE UPPER
LFP	1.77	3.35	0.75	-.37	3.91
RFP	0.28	0.70	0.16	-.17	0.72
LFP/RFP RATIO	8.77	4.86	1.09	8.76	8.79
HEART RATE	139	19.60	4.38	139	139

GROUP B, CRITICAL

PARAMETER	MEAN	STD.DEV.	STD. ERROR OF MEAN	99% CONFIDENCE LOWER	99% CONFIDENCE UPPER
LFP	.05	.03	.01	.02	.07
RFP	.10	.09	.03	.01	.18
LFP/RFP RATIO	.83	.51	.15	.83	.83
HEART RATE	142	24.32	7.02	142	142

The discriminate value for the LFP/RFP ratio was two. In Group A, the range of LFP/RFP ratios was 3 to 22 (arithmetic mean 8.77). The range of RFPs was 0.01 to 3.13 (arithmetic mean 0.28) and the range of LFPs was 0.09 to 13.88 (arithmetic mean 1.77). In Group

B, the range of LFP/RFP ratios was 0.17 to 1.9 (arithmetic mean 0.83), the ratio of RFPs was 0.02 to 0.32 (arithmetic mean 0.1), and the range of LFPs was 0.01 to 0.1 (arithmetic mean 0.5)

Although the mean value of the LFP/RFP ratio was greater than two for Group I, the ratio for the stable patients fell below two for brief periods. That which distinguishes the stable from the critical patients is the sustained value for greater than or about one hour of the LFP/RFP ratio for the critical group.

The results are graphically depicted in Figs. 19, 17 and 18. In Figs. 16 and 17, each heavy dot A represents a geometric mean, each light line B indicates the standard error of the geometric mean and each heavy line C represents the standard deviation of the geometric mean. In Fig. 18, each heavy dot A represents an arithmetic mean, each set of slashes B1 and B2 represents the standard error of the arithmetic mean and each set of slashes C1 and C2 represents the standard deviation of the arithemetic mean.

The significance of heart rate spectral analysis for diagnosis of cardiovascular stress and the prediction of fatality is highlighted by the fact that patients with a low LFP/RFP ratio underwent a cardiac arrest even in the presence of otherwise normal vital signs. No patient with a LFP/RFP ratio greater than two experienced a cardiac arrest.

Infusion of pressors, alone or in combination with vasodilators, did not induce a low LFP/RFP ratio.

Four patients in Group III had LFP/RFP ratios less than two during their critical periods. For the three of these four patients who were restudied during their recovery periods, all three had LFP/RFP ratios greater than two.

The mean LFP for Group B [0.05 (Beats per

minute)^2] was less than the mean LFP for Group A [1.77 beats per minute)^2], p <0.0001. There was no significant difference between the mean RFP between the groups.

The initial LFP/RFP ratios for the patients with isolated coarctation of the aorta ranged up to 10,000. The LFP/RFP ratios observed for this group immediately after an operation to correct the condition were within the range for Group A patients. Two patients had LFP/RFP ratios greater than 100 before discharge from the intensive care unit. These ratios were correlated with mild to moderate congestive heart failure. One of these patients died suddenly at approximately 2-1/2 months after the operation. The other two patients remained alive and well.

Although the LFP/RFP ratio provided the sharpest discrimination between stable and critical patients in these studies, the LFP alone discriminated between Groups A and B, p <0.0001. Neither respiratory frequency peak power nor mean heart rate distinguished between Groups A and B. On the other hand, LFP/RFP ratios and LFP levels low levels sustained for greater than or about one hour correlate with the course of the conditions of patients who experienced cardiac arrest or severe hypotensive episodes but later recovered.

Although stable patients experienced transient depression of levels of LFP and of the LFP/RFP ratio, depression of these factors for about an hour or more never failed to predict a critical status.

No significant difference was observed between freely ventilating patients and mechanically ventilated patients. Eighteen out the twenty patients in Group A were mechanically ventilated and all twelve of the Group B patients were mechanically ventilated.

All patients in Group B received inotropic support while more than half of the patients in the

Group A received at least some inotropic support. The cardiac diagnoses of all of the patients in Group B and for some of the patients in Group A were known to be associated with high mortality. All of the patients in Group B underwent deep hypothermic circulatory arrest during their operations. Of the twenty patients in Group A, nine had extra cardiac surgery (i.e. not involving cardiopulmonary bypass or deep hypothermic circulatory arrest). Three of the patients in Group II did not undergo operations. Therefore, it is not believed that differences in treatment or disease specific pathology alone explained the low values LFP and the low LFP/RFP ratios in Group B patients but that the low values actually reflect a vulnerable circulatory state.

It has also been observed that the value of LFP and of the LFP/RFP ratio increase in moderate to severe heart failure but decreased to subnormal values in end stage myocardial failure. Thus, these two spectral parameters may indicate cardiovascular regulatory effectiveness (cardiovascular regulatory reserve) during the stress of heart failure.

This analysis is consistent with previous physiological studies which indicated that low frequency heart fluctuations may be mediated by both the beta-sympathetic and parasympathetic mechanisms while respiratory fluctuations are exclusively mediated by parasympathetic mechanisms. It is also consistent with this analysis that LFP has been observed to increase during conditions which elicit enhanced sympathetic activity, such as acute hypoxia, postural changes, hemmorhage and aortic constriction. In this light, the LFP/RFP ratio may represent a measure of the balance between beta adrenergic and parasympathetic modulation of cardiac function.

Thus, the increase in LFP and in the LFP/RFP

ratio for patients with isolated coarctation of the aorta and moderate heart failure may result from an increased activity from the sympathetic mechanism and a decreased activity of the parasympathetic mechanism. On the other hand, the decreased level of LFP and of the LFP/RFP ratio found in critical patients may be due to non-responsiveness of the sympathetic mechanism. Sympathetic non-responsiveness may be due to myocardial catecholamaine depletion alone or in combination with the observed down regulation of beta receptors from cardiac tissue in the end stage of heart failure.

EXAMPLE 2

In patients undergoing operations, shifts in body fluid disposition during surgery may lead to changes in intervascular volume (i.e. a shift of fluid out of a circulatory tree of blood vessels). Accordingly, the availability of the method of diagnosing cardiovascular stress as described in Example 1 may be used to choose among various protocols for treatment or to justify a radical change in medical or surgical treatment.

For example, by monitoring a patient with the real time heart rate frequency spectral monitor according to the present invention during administration of anesthesia, an anesthesiologist may non-invasively monitor intravascular volume status. Upon observing an increase in the LFP or in the LFP/RFP ratio, the anesthesiologist may increase the amount of fluids administered by way of intravenous injection or may take steps to reverse effects of a particular anesthetic.

It is a particular advantage of the apparatus according to the present invention that heart rate fluctuation spectral analysis may be done in real time. This capability permits correlation of treatment administered with changes in LFP or LFP/RFP ratios.

Although the present invention has been described in terms of preferred embodiments, it is understood that modifications, variations and improvements will occur to those skilled in the art. For example, it will occur to those skilled in the art to employ the present invention for monitoring cardiovascular instability in the following settings in which significant circulatory stress are commonly observed: Labor and Delivery Room; Operating Room; Cardiac Catheterization Laboratory; Neonatal, Pediatric, Adult Medical, Adult Surgical, Cardiothoracic and Neurosurgical Intensive Care Units; Coronary Care Units; Burn Units; and Emergency Rooms.

The present invention may also be used for monitoring cardiovascular instability in the following patients in which adjustments in cardiovascular regulation may provide a central key to understanding the efficiency and efficacy of treatment. Ambulatory patients with known heart disease in which sudden cardiac death is a common association, one example of which would be a patient with a congestive cardiomyopathy who is being treated with vasodialator drugs and for whom the LFP/RFP ratio has changed from a normal baseline level to decreased levels may then subsequently be either admitted to the hospital for adjustment of medications and/or observed and monitored in the physician's office while his vasodialator drug dose is increased. A patient with renal disease (e.g. one who requires dialysis) may exhibit a marked increase in LFP and LFP/RFP ratio secondary to the onset of incipient moderate congestive heart failure would thus be treated by dialysis to relieve a congested circulatory state; a patient with moderate to severe pulmonary disease resulting in hypoxemia and/or hypercarbia who requires bronchodialator and/or supplementary oxygen and/or mechanical ventilation (e.g.

a patient who exhibits a marked decrease in LFP/RFP ratio secondary to myocardial failure due to a profound imbalance between myocardial ventricular output and oxygen demand), may be treated by adjustments in bronchodialator drugs, diuretics, and/or ventilator adjustments.

A premature infant of very low birth weight known to be at risk for intraventricular hemorrhage may, for example, develop a slow intracranial bleed associated with an abrupt increase in LFP, which may alert physicians prior to a brisk bleed thus allowing institution of appropriate changes in medical management to limit substantially known risk factors that may predispose to such an event, or may permit recognition of the presence of unsuspected circumstances that contribute to the bleed. In neurologic disease, such as one in which a patient has sustained a major intracerebral event (e.g. neurosurgical evacuation of a space occupying lesion such as a tumor or blood), a patient may, for example, exhibit a markedly attenuated LFP/RFP ratio, secondary to massively increased parasympathetic activity which would markedly increase RFP, at the expense of LFP, but which may or may not be associated with signs of increased intracranial pressure, and which may be treated by, for example, hyperventillation, rapid diuresis, or burr hole placement.

A patient with severe systemic infection may exhibit shock secondary to the infection process may, for example, exhibit an elevated LFP/RFP ratio which may then be subsequently used by the physician in managing the shock state by means of pressor agents and infusion of significant volumes of fluid, thus providing the physician an indication of how effectively he is treating the shocked state above and beyond the traditional measurements such as systemic blood pressure

and cardiac output. A patient with hematologic disease associated with anemia, such as Sickle Cell Anemia, exhibits an oscillation in capillary blood flow when severly anemic at the frequency associated with LFP and may exhibit large values for LFP, and for the LFP/RFP ratio may, for example, be treated by blood transfusion which may lead to an expected decrease in LFP, LFP/RFP ratio, and thus enable the physician to monitor by means of heart rate spectral analysis appropriate timing for transfusion therapy. A fetus prior to delivery, may for example, exhibit a marked attenuation in LFP associated with severe fetal distress, and may thus alert the physician to perform an emergency Caesarean section.

One skilled in the art understands that the calibrators according to the present invention may be adjusted to simulate disease states as well as normal conditions. It is also understood that the present invention is not limited to use with patients whose primary disease is of the heart but that modifications may be made for use with such patients.

Lastly, it is clear to one skilled in the art that durations and ranges for levels of LFP and LFP/RFP ratios are conservatively stated herein and that variations from these ranges and durations are contemplated within the scope of the equivalents of the present invention.

Therefore, it is intended that the methods and apparatus according to the present invention to be given the broadest scope allowable for the invention as claimed.

APPENDIX A

```
10 Summary3:!
20      !This program takes data already collected and
         allows the data
30      !to be outputted to a printer
40      !2 MAY 1985
50      !
60      COM /Trends/ Mean_hr_t(60),Lfa_t(60),Rfa_
        t(60),Ratio_t(60),T_ptr,Time_now1,Mean_resp_
          t(60),Trend_dp
70      COM /Multi_param/ Start_chan,Stop_chan,Pacing_
        bits,Pacing_rate,Num_pts,Nu
          m_xfer,Num_xfer_left,Name_len,Scr_file$[28],Scr_
          file2$[28]
80      COM /Pressure/
        Top1,Top2,Top3,Top4,Bot1,Bot2,Bot3,Bot4
90      COM /Editor/ Edit_msg$[80]
100     COM /Subject/ Sub_name$[25],Hos_num$[15],Id_
        age$[10],Id_wt$[10],Id_ht$[10
          ],Diag$[30],Opera$[45],Halt_pg,In_file$[6]
110     COM /Io_chart/ Io_time$(8)[10],Iv_intake(8),Fluid_
        in(8),In_tot(8),Urine(8
          ),Chest(8),Out_tot(8),Net(8),Io_ptr
120     COM /Lab_chart/ Lab_
    time$(8)[10],Na(8),K1(8),Cl(8),Hco3(8),Ca(8),Hct(8),G
     luc(8),Dig(8),Pt(8),Ptt(8),Creat(8),Bun(8),Lab_ptr
130     COM /Vent_chart/ Vent_
      time$(8)[15],Rate(8),Fio2(8),Pp(8),Peep(8),Tv(8),
        Ie_ratio$(8)[5],Airp(8),Ph(8),Po2(8),
          Pco2(8),Bgo3(8),Be(8),Vent_ptr
140     COM /Pres_chart/ Pres_time$(20)[15],Ao_s(20),Ao_
        d(20),Ao_m(20),Pa_s(20),P
           a_d(20),Pa_m(20),La_m(20),Ra_m(20),Pres_
```

```
          ptr,Pres_in
150    COM /Heart_index/ Heart_
     time$(15)[15],Ci(15),Pvri(15),Svri(15),Heart_ptr
160    COM /Drugs/ Drug_time$(40)[20],Drug_
       name$(40)[40],Drug_dos$(40)[20],Drug_
          ptr
170    DIM Msg_buffer$[6400] BUFFER
180    DIM Pres_p(20),Io_p(8),Lab_p(8),Vent_p(8),Heart_
         p(5),Drug_p(40)
190    INPUT "enter date on which data was collected
       (ddmmyy) e.g. 22AP85",In_file$
200    Disk1$=":HP8290X,700,1"
210    INPUT "is the trend file named 'trnd'(1) or 'temp_
       trend'(2)?",Ans
220    IF Ans=2 THEN
230        ASSIGN @Trend_file TO "temp_
           trend"&Disk1$;FORMAT OFF
240        ASSIGN @Messages TO "messglog"&Disk1$;FORMAT
           OFF
250        ASSIGN @Hemo_data TO "hemo_
           data"&Disk1$;FORMAT OFF
260        ASSIGN @Io_data TO "io_data"&Disk1$;FORMAT
           OFF
270        ASSIGN @Lab_data TO "lab_data"&Disk1$;FORMAT
           OFF
280        ASSIGN @Vent_data TO "vent_
           data"&Disk1$;FORMAT OFF
290        ASSIGN @Co_data TO "co_data"&Disk1$;FORMAT
           OFF
300        ASSIGN @Drug_data TO "drug_
           data"&Disk1$;FORMAT OFF
310        ASSIGN @Sub_data TO "sub_data"&Disk1$;FORMAT
           OFF
320        ON END @Trend_file GOTO Start
330        FOR I=0 TO 55
340            ENTER @Trend_file;Trans_t(I),Mean_hr_
```

```
                t(I),Lfa_t(I),Rfa_t(I),Ratio
                 _t(I),Mean_resp_t(I)
350         NEXT I
360              T_ptr=I
370         Num_xfer=T_ptr
380     ELSE
390         ASSIGN @Trend_file TO "trnd"&In_
            file$&Disk1$;FORMAT OFF
400         ASSIGN @Messages TO "msgs"&In_
            file$&Disk1$;FORMAT OFF
410         ASSIGN @Hemo_data TO "hemo"&In_
            file$&Disk1$;FORMAT OFF
420         ASSIGN @Io_data TO "io__"&In_
            file$&Disk1$;FORMAT OFF
430         ASSIGN @Lab_data TO "lab_"&In_
            file$&Disk1$;FORMAT OFF
440         ASSIGN @Vent_data TO "vent"&In_
            file$&Disk1$;FORMAT OFF
450         ASSIGN @Co_data TO "co__"&In_
           file$&Disk1$;FORMAT OFF
460         ASSIGN @Drug_data TO "drug"&In_
            file$&Disk1$;FORMAT OFF
470         ASSIGN @Sub_data TO "sub_"&In_
            file$&Disk1$;FORMAT OFF
480         ENTER @Trend_file;Mean_hr_t(*),Lfa_t(*),Rfa_
            t(*),Ratio_t(*),Mean_resp
               _t(*),Trans_time(*),T_ptr
490         Num_xfer=T_ptr
500     END IF
510        ASSIGN @Trend_file TO *
520     ON END @Hemo_data GOTO Hemo1
530     FOR I=0 TO 20
540         ENTER @Hemo_data;Pres_time$(I),Ao_s(I),Ao_
            d(I),Ao_m(I),Pa_s(I),Pa_d(I
             ),Pa_m(I),La_m(I),Ra_m(I),Pres_p(I)
550     NEXT I
```

```
560 Hemol:ASSIGN @Hemo_data TO *
570     Pres_ptr=I-1
580     ON END @Io_data GOTO Iol
590     FOR I=0 TO 8
600         ENTER @Io_data;Io_time$(I),Iv_intake(I),Fluid_
            in(I),In_tot(I),Urine(I
              ),Chest(I),Out_tot(I),Net(I),Io_p(I)
610     NEXT I
620 Iol:ASSIGN @Io_data TO *
630     Io_ptr=I-1
640     ON END @Lab_data GOTO Labl
650     FOR I=0 TO 8
660         ENTER @Lab_data;Lab_
     time$(I),Na(I),Kl(I),Cl(I),Hco3(I),Ca(I),Hct(I),G
     luc(I),Dig(I),Pt(I),Ptt(I),Creat(I),Bun(I),Lab_p(I)
670     NEXT I
680 Labl:ASSIGN @Lab_data TO *
690     Lab_ptr=I-1
700     ON END @Vent_data GOTO Ventl
710     FOR I=0 TO 8
720         ENTER @Vent_data;Vent_
      time$(I),Rate(I),Fio2(I),Pp(I),Peep(I),Tv(I),
       Ie_ratio$(I),Airp(I),Ph(I),Po2(I),
         Pco2(I),Bgo3(I),Be(I),Vent_p(I)
730     NEXT I
740 Ventl:ASSIGN @Vent_data TO *
750     Vent_ptr=I-1
760     ON END @Co_data GOTO Col
770     FOR I=0 TO 5
780         ENTER @Co_data;Heart_
            time$(I),Ci(I),Pvri(I),Svri(I),Heart_p(I)
790     NEXT I
800 Col:ASSIGN @Co_data TO *
810     Heart_ptr=I-1
820     ON END @Drug_data GOTO Drugl
830     FOR I=0 TO 40
```

```
840         ENTER @Drug_data;Drug_time$(I),Drug_
            name$(I),Drug_dos$(I),Drug_p(I)
850     NEXT I
860 Drug1:ASSIGN @Drug_data TO *
870     Drug_ptr=I-1
880          !
890          !
900          !
910     Pacing_rate=250
920     Time_now1=TIMEDATE MOD 86400
930     Out_graph=1
        !....graphics
        dump
940     Trend_dp=2
950     CALL Trend_graph
960     CALL Graph_dump(Out_graph)
970     Trend_dp=1
980     CALL Trend_graph
990     CALL Graph_dump(Out_graph)
1000   !
1010 Chart_dump:!
1020    ENTER @Sub_data;Sub_name$,Hos_num$,Id_age$,Id_
        wt$,Id_ht$,Diag$,Opera$
1030    ASSIGN @Sub_data TO *
1040    Out_graph=2
1050    FOR I=1 TO 5
1060        CALL Chart(I)
1070    CALL Graph_dump(Out_graph)         !....chart dump
1080    NEXT I
1090    !
1100    !
1110 Msg_dump:  !
1120    IF Ans=1 THEN
1130        ASSIGN @Msg_file TO "msgs"&In_
            file$&Disk1$;FORMAT OFF
1140    ELSE
```

```
1150        ASSIGN @Msg_file TO "messglog"&Disk1$;FORMAT
            OFF
1160    END IF
1170    PRINTER IS 701
1180    ASSIGN @Msg_buffer TO BUFFER Msg_buffer$
1190    STATUS @Msg_file,3;Num_rec
1200    STATUS @Msg_file,4;Rec_len
1210    STATUS @Msg_file,7;Eof_rec
1220    STATUS @Msg_file,8;Eof_byte
1230    Num_bytes=(Eof_rec-1)*Rec_len+Eof_byte-1
1240 Read_msg:TRANSFER @Msg_file TO @Msg_buffer;COUNT
     Num_bytes,WAIT
1250    ASSIGN @Msg_file TO *
1260    ASSIGN @Msg_buffer TO *
1270    Cur_ptr=1
1280        PRINT USING Image_wt1;Sub_name$,Hos_num$,In_
            file$
1290 Image_wt1:IMAGE    "Name: ",K,XXXX,"Hosp num:
                        ",K,XXXXX,K
1300        PRINT USING Image_wt2;Id_age$,Id_wt$,Id_
            ht$,Diag$,Opera$
1310 Image_wt2:IMAGE    "Age: ",K,XXXX,"Wt(kg):
            ",K,XXXX,"Ht(cm): ",K,XXXX,"Diag:
            ",K,XXXX,"Op: ",K
1320 Next_msg:!
1330    Beg_msg=POS(Msg_buffer$[4],"Time")+3
1340    IF Beg_msg=3 THEN GOTO Stopper
1350    PRINT Msg_buffer$[1,Beg_msg-1]
1360    Msg_buffer$=Msg_buffer$[Beg_msg]
1370    GOTO Next_msg
1380 Stopper:!PRINTER IS 1
1390    STOP
1400    END
1410        !
1420    !
1430    !This subroutine prints the graphics
```

```
1440   !
1450   !
1460   SUB Trend_graph
1470 !
1480        COM /Trends/ Mean_hr_t(*),Lfa_t(*),Rfa_
            t(*),Ratio_t(*),T_ptr,Time_now
              1,Meas_resp_t(*),Trend_dp,Trans_time(*)
1490        COM /Multi_param/ Start_chan,Stop_chan,Pacing_
            bits,Pacing_rate,Num_pt
             s,Num_xfer,Num_xfer_left,Name_len,Scr_
               file$[28],Scr_
            file2$[28]
1500        COM /Pressure/
            Top1,Top2,Top3,Top4,Bot1,Bot2,Bot3,Bot4
1510        COM /Pres_chart/ Pres_time$(*),Ao_s(*),Ao_
            d(*),Ao_m(*),Pa_s(*),Pa_d(*
              ),Pa_m(*),La_m(*),Ra_m(*),Pres_ptr,Pres_in
1520        DIM First_line(60),Sec_line(60),Third_
            line(60),Fourth_line(60)
1530        IF Trend_dp=1 THEN
                MAT First_line= Ao_m
1540            MAT First_line= Ao_m
1550            MAT Sec_line= Pa_m
1560            MAT Third_line= La_m
1570            MAT Fourth_line= Ra_m
1580            G_right=INT((Num_xfer*256/60)/15)
1590            Trend_ptr=Pres_ptr
1600            Top1=150
1610            Bot1=0
1620            Top2=75
1630            Bot2=0
1640            Top3=50
1650            Bot3=0
1660            Top4=50
1670            Bot4=0
1680        ELSE
1690            MAT First_line= Mean_hr_t
```

```
1700             MAT Sec_line= Ratio_t
1710             MAT Third_line= Lfa_t
1720             MAT Fourth_line= Rfa_t
1730             G_right=Num_xfer
1740             Trend_ptr=T_ptr
1750             Top1=200
1760             Bot1=0
1770             Top2=2.5
1780             Bot2=-2.5
1790             Top3=10
1800             Bot3=0
1810             Top4=10
1820             Bot4=0
1830         END IF
1840         Block_time=Pacing_rate*1.024/3600.
1850         GINIT
1860         GCLEAR
1870         PRINT CHR$(12)
1880         GRAPHICS ON
1890         Beg_time=Time_now1/3600-Block_time
1900         End_time=Beg_time+Num_xfer*Block_time
1910         Ibeg_time=INT(Beg_time)
1920         IF Ibeg_time<Beg_time THEN Ibeg_time=Ibeg_
             time+1
1930 !
1940 ! label the time axes
1950 !
1960         VIEWPORT 0,128,45,50
1970         WINDOW Beg_time,End_time,0,1
1980         IF INT(End_time)>Beg_time THEN
1990             LDIR 0
2000             FOR T_label=Ibeg_time TO INT(End_time)
2010                 MOVE T_label,.5
2020                 LORG 5
2030                 CSIZE 4
2040                 LABEL T_label
```

```
2050            NEXT T_label
2060        END IF
2070        VIEWPORT 0,128,40,45
2080        WINDOW 0,1,0,1
2090        MOVE .5,0
2100        LORG 4
2110        LABEL "Time (24 hr)"
2120 !
2130 ! draw the axes
2140 !
2150        VIEWPORT 0,128,50,100
2160        WINDOW Beg_time,End_time,0,1
2170        AXES 1/15.,.1,Beg_time,0
2180        WINDOW 1,0,1,0
2190        AXES 0,.25,0,0
2200 !
2210 ! mean heart rate trends
2220 !
2230        WINDOW -1,G_right,Bot1,Top1
2240        MOVE 0,First_line(0)
2250        FOR I=0 TO Trend_ptr-1
2260            DRAW I,First_line(I)
2270        NEXT I
2280 !
2290 ! ratio trends (with a line at ratio=2)
2300 !
2310        WINDOW -1,G_right,Bot2,Top2
2320        LINE TYPE 8,5
2330        IF Trend_dp=2 THEN
2340            MOVE 0,LGT(Sec_line(0))
2350        ELSE
2360            MOVE 0,Sec_line(0)
2370        END IF
2380        FOR I=0 TO Trend_ptr-1
2390            IF Trend_dp=2 THEN
2400                DRAW I,LGT(Sec_line(I))
```

```
2410          ELSE
2420              DRAW I,Sec_line(I)
2430          END IF
2440      NEXT I
2450      IF Trend_dp=2 THEN
2460          LINE TYPE 3,5!..sparsely dotted line at
                  ratio=2
2470          MOVE 0,LGT(2.)
2480          DRAW Trend_ptr-1,LGT(2.)
2490      END IF
2500 !
2510 ! lfa trends
2520 !
2530      WINDOW -1,G_right,Bot3,Top3
2540      LINE TYPE 4,5
2550      MOVE 0,Third_line(0)
2560      FOR I=0 TO Trend_ptr-1
2570          DRAW I,Third_line(I)
2580      NEXT I
2590 !
2600 ! rfa trends
2610 !
2620      WINDOW -1,G_right,Bot4,Top4
2630      LINE TYPE 5,5
2640      MOVE 0,Fourth_line(0)
2650      FOR I=0 TO Trend_ptr-1
2660          DRAW I,Fourth_line(I)
2670      NEXT I
2680 !
2690 ! draw a key for line types
2700 !
2710      VIEWPORT 64,128,0,50
2720      WINDOW 0,1,0,13
2730      IF Trend_dp=2 THEN
2740          PRINT TABXY(1,17);"trend graph"
2750          PRINT TABXY(55,15);"mean hr(0-200)"
```

```
2760            PRINT TABXY(55,16);"ratio(.01-100)"
2770            PRINT TABXY(55,17);"lfa    (0-10)"
2780            PRINT TABXY(55,18);"rfa    (0-10)"
2790        ELSE
2800            PRINT TABXY(1,17);"mean pressure graphs"
2810            PRINT TABXY(50,15);"ao pressure(0-150)"
2820            PRINT TABXY(50,16);"pa pressure(0-75)"
2830            PRINT TABXY(50,17);"la pressure(0-50)"
2840            PRINT TABXY(50,18);"ra pressure(0-50)"
2850        END IF
2860        LINE TYPE 1,5
2870        MOVE .8,11
2880        DRAW 1.,11
2890        LINE TYPE 8,5
2900        MOVE .8,10
2910        DRAW 1.,10
2920        LINE TYPE 4,5
2930        MOVE .8,9
2940        DRAW 1.,9
2950        LINE TYPE 5,5
2960        MOVE .8,8
2970        DRAW 1.,8
2980    SUBEND
2990 !
3000 !
3010 !This subroutine prints the charts
3020 !
3030 !
3040    SUB Chart(Chart_num)
3050        COM /Subject/ Sub_name$,Hos_num$,Id_age$,Id_
        wt$,Id_ht$,Diag$,Opera$,H
          alt_pg,In_file$
3060        COM /Io_chart/ Io_time$(*),Iv_intake(*),Fluid_
        in(*),In_tot(*),Urine(*
          ),Chest(*),Out_tot(*),Net(*),Io_ptr
3070        COM /Lab_chart/ Lab_
```

```
time$(*),Na(*),Kl(*),Cl(*),Hco3(*),Ca(*),Hct(*),G
   luc(*),Dig(*),Pt(*),Ptt(*),Creat(*),Bun(*),Lab_
     ptr
3080        COM /Vent_chart/ Vent_
time$(*),Rate(*),Fio2(*),Pp(*),Peep(*),Tv(*),
Ie_ratio$(*),Airp(*),Ph(*),Po2(*),Pco2(*),
 Bgo3(*),Be(*),Vent_ptr
3090        COM /Pres_chart/ Pres_time$(*),Ao_s(*),Ao_
            d(*),Ao_m(*),Pa_s(*),Pa_d(*
            ),Pa_m(*),La_m(*),Ra_m(*),Pres_ptr,Pres_in
3100        COM /Pressure/
                  Top1,Top2,Top3,Top4,Bot1,Bot2,Bot3,Bot4
3110        COM /Heart_index/ Heart_
            time$(*),Ci(*),Pvri(*),Svri(*),Heart_ptr
3120        COM /Drugs/ Drug_time$(*),Drug_name$(*),Drug_
            dos$(*),Drug_ptr
3130        Out_graph=2
3140        Pres_stl=0
3150        Lab_stl=0
3160        Io_stl=0
3170        Vent_stl=0
3180        Drug_stl=0
3190        Io_p=Io_ptr
3200        Lab_p=Lab_ptr
3210        Vent_p=Vent_ptr
3220        Pres_p=Pres_ptr
3230        Heart_p=Heart_ptr
3240        Drug_p=Drug_ptr
3250        !
3260        ! set up identifying subject info
3270        !
3280        GRAPHICS OFF
3290        PRINT CHR$(12)
3300        PRINT TABXY(1,1);
3310        PRINT USING Image_wtl;Sub_name$,Hos_num$,In_
            file$
```

```
3320 Image_wtl:IMAGE   "Name: ",K,XXXX,"Hosp num:
                       ",K,XXXXX,K
3330        PRINT TABXY(1,2);
3340        PRINT USING Image_wt2;Id_age$,Id_wt$,Id_
            ht$,Diag$,Opera$
3350 Image_wt2:IMAGE   "Age: ",K,XXXX,"Wt(kg):
            ",K,XXXX,"Ht(cm): ",K,XXXX,"Diag:
            ",K,XXXX,"Op: ",K
3360        !
3370        ! go to appropriate chart
3380        !
3390        ON Chart_num GOTO In_out,Lab_val,Vent_
            val,Pres_val,Drug
3400 In_out:!                          ....intake/output
3410       ! IF Io_ptr>3 THEN Io_stl=2
3420       ! IF Io_ptr>5 THEN
3430       !     DISP "do not input more Intake/Output
           !     data; disc full"
3440       !     WAIT 3
3450       !     SUBEXIT
3460       ! END IF
3470        PRINT TABXY(30,3);"INTAKE/OUTPUT CHART"
3480        PRINT TABXY(1,4);"Intake (cc/hr) "
3490        PRINT TABXY(1,5);"Time"
3500        PRINT TABXY(4,6);"Maint. Fluid"
3510        PRINT TABXY(4,7);"Other Fluids"
3520        PRINT TABXY(1,9);"Total "
3530        PRINT TABXY(1,11);"Output (cc/hr)"
3540        PRINT TABXY(4,12);"Urine"
3550        PRINT TABXY(4,13);"Chest"
3560        PRINT TABXY(1,15);"Total"
3570        PRINT TABXY(1,17);"Net I/O"
3580        Start=25
3590        IF Io_ptr>3 THEN Io_p=3
3600 Io_dp:FOR I=Io_stl TO Io_p
3610            PRINT TABXY(Start,5);Io_time$(I)
```

```
3620             PRINT TABXY(Start,6);Iv_intake(I)
3630             PRINT TABXY(Start,7);Fluid_in(I)
3640             PRINT TABXY(Start,9);In_tot(I)
3650             PRINT TABXY(Start,12);Urine(I)
3660             PRINT TABXY(Start,13);Chest(I)
3670             PRINT TABXY(Start,15);Out_tot(I)
3680             PRINT TABXY(Start,17);Net(I)
3690             Start=Start+10
3700         NEXT I
3710         IF Io_ptr>Io_p THEN
3720             INPUT "more data on next page - do you
                 want this dumped to printe
                   r? (Y/N)",Ans$
3730             IF Ans$="Y" OR Ans$="y" THEN CALL Graph_
                 dump(Out_graph)
3740             Io_stl=4
3750             Io_p=Io_ptr
3760             Start=25
3770             FOR J=5 TO 17
3780             PRINT TABXY(Start,J);"        "
3790             NEXT J
3800             GOTO Io_dp
3810         END IF
3820         GOTO Finish
3830 !
3840 !
3850 Lab_val:!                                   ...lab values
3860        !IF Lab_ptr>3 THEN Lab_stl=2
3870        !IF Lab_ptr>5 THEN
3880        !    DISP "do not input any more lab values;
            !    disc full"
3890        !    WAIT 3
3900        !    SUBEXIT
3910        !END IF
3920         PRINT TABXY(30,3);"Lab Values"
3930         PRINT TABXY(10,4);"Time"
```

```
3940        PRINT TABXY(1,6);"Na"
3950        PRINT TABXY(1,7);"K"
3960        PRINT TABXY(1,8);"Cl"
3970        PRINT TABXY(1,9);"HCO3"
3980        PRINT TABXY(1,10);"Ca"
3990        PRINT TABXY(1,11);"Hct"
4000        PRINT TABXY(1,12);"Glucose"
4010        PRINT TABXY(1,13);"Dig level"
4020        PRINT TABXY(1,14);"PT"
4030        PRINT TABXY(1,15);"PTT"
4040        PRINT TABXY(1,16);"Creat"
4050        PRINT TABXY(1,17);"Bun"
4060        Start=15
4070        IF Lab_ptr>3 THEN Lab_p=3
4080 Lab_dp:FOR I=Lab_stl TO Lab_p
4090            PRINT TABXY(Start+10,4);Lab_time$(I)
4100            PRINT TABXY(Start+10,6);Na(I)
4110            PRINT TABXY(Start+10,7);Kl(I)
4120            PRINT TABXY(Start+10,8);Cl(I)
4130            PRINT TABXY(Start+10,9);Hco3(I)
4140            PRINT TABXY(Start+10,10);Ca(I)
4150            PRINT TABXY(Start+10,11);Hct(I)
4160            PRINT TABXY(Start+10,12);Gluc(I)
4170            PRINT TABXY(Start+10,13);Dig(I)
4180            PRINT TABXY(Start+10,14);Pt(I)
4190            PRINT TABXY(Start+10,15);Ptt(I)
4200            PRINT TABXY(Start+10,16);Creat(I)
4210            PRINT TABXY(Start+10,17);Bun(I)
4220            Start=Start+10
4230        NEXT I
4240        IF Lab_ptr>Lab_p THEN
4250            INPUT "more data on next page - do you
            want this dumped to printe
             r? (Y/N)",Ans$
4260            IF Ans$="Y" OR Ans$="y" THEN CALL Graph_
            dump(Out_graph)
```

```
4270            Lab_stl=4
4280            Lab_p=Lab_ptr
4290            Start=15
4300            FOR J=4 TO 17
4310            PRINT TABXY(Start,J);"      "
4320            NEXT J
4330            GOTO Lab_dp
4340        END IF
4350        GOTO Finish
4360!
4370!
4380 Vent_val:!                ....ventilation values
4390      ! IF Vent_ptr>3 THEN Vent_stl=2
4400      ! IF Vent_ptr>5 THEN Vent_stl=4
4410      ! IF Vent_ptr>7 THEN
4420      !      DISP "do not input any more Vent values;
                 disc full"
4430      !      WAIT 3
4440      !      SUBEXIT
4450      ! END IF
4460        PRINT TABXY(30,3);"VENTILATION"
4470        PRINT TABXY(1,4);"Settings          Hour:"
4480        PRINT TABXY(4,5);"Rate"
4490        PRINT TABXY(4,6);"FIO2"
4500        PRINT TABXY(4,7);"Peak Pres"
4510        PRINT TABXY(4,8);"Peep"
4520        PRINT TABXY(4,9);"TV"
4530        PRINT TABXY(4,10);"I:E ratio"
4540        PRINT TABXY(4,11);"Mean air"
4550        PRINT TABXY(1,12);"Blood Gases"
4560        PRINT TABXY(4,13);"ph"
4570        PRINT TABXY(4,14);"pO2"
4580        PRINT TABXY(4,15);"pCO2"
4590        PRINT TABXY(4,16);"HCO3"
4600        PRINT TABXY(4,17);"BE"
4610        Start=15
```

```
4620        IF Vent_ptr>3 THEN Vent_p=3
4630 Vent_dp:FOR I=Vent_stl TO Vent_p
4640            PRINT TABXY(Start+10,4);Vent_time$(I)
4650            PRINT TABXY(Start+10,5);Rate(I)
4660            PRINT TABXY(Start+10,6);Fio2(I)
4670            PRINT TABXY(Start+10,7);Pp(I)
4680            PRINT TABXY(Start+10,8);Peep(I)
4690            PRINT TABXY(Start+10,9);Tv(I)
4700            PRINT TABXY(Start+10,10);Ie_ratio$(I)
4710            PRINT TABXY(Start+10,11);Airp(I)
4720            PRINT TABXY(Start+10,13);Ph(I)
4730            PRINT TABXY(Start+10,14);Po2(I)
4740            PRINT TABXY(Start+10,15);Pco2(I)
4750            PRINT TABXY(Start+10,16);Bgo3(I)
4760            PRINT TABXY(Start+10,17);Be(I)
4770            Start=Start+10
4780        NEXT I
4790        IF Vent_ptr>Vent_p THEN
4800            INPUT "more data on next page - do you
                want this dumped to printe
                  r? (Y/N)",Ans$
4810            IF Ans$="Y" OR Ans$="y" THEN CALL Graph_
                dump(Out_graph)
4820            Vent_stl=4
4830            Vent_p=Vent_ptr
4840            Start=15
4850            FOR J=4 TO 17
4860            PRINT TABXY(Start,J);"      "
4870            NEXT J
4880            GOTO Vent_dp
4890        END IF
4900        GOTO Finish
4910 !
4920 !
4930 Pres_val:!                       ....pressure values
4940       !IF Pres_ptr>12 THEN Pres_stl=5
```

```
4950        PRINT TABXY(9,3);"Time:"
4960        PRINT TABXY(1,4);"Systemic"
4970        PRINT TABXY(4,5);"systolic"
4980        PRINT TABXY(4,6);"diastolic"
4990        PRINT TABXY(4,7);"mean"
5000        PRINT TABXY(1,8);"Pulmonary"
5010        PRINT TABXY(4,9);"systolic"
5020        PRINT TABXY(4,10);"diastolic"
5030        PRINT TABXY(4,11);"mean"
5040        PRINT TABXY(1,12);"LA mean"
5050        PRINT TABXY(1,13);"RA mean"
5060        PRINT TABXY(9,14);"Time: "
5070        PRINT TABXY(1,15);"C.I."
5080        PRINT TABXY(1,16);"PVRI"
5090        PRINT TABXY(1,17);"SVRI"
5100        Start=15
5110        IF Pres_ptr>12 THEN Pres_p=12
5120 Pres_dp:FOR I=Pres_stl TO Pres_p
5130            PRINT TABXY(Start,3);Pres_time$(I)
5140            PRINT TABXY(Start,5);Ao_s(I)
5150            PRINT TABXY(Start,6);Ao_d(I)
5160            PRINT TABXY(Start,7);Ao_m(I)
5170            PRINT TABXY(Start,9);Pa_s(I)
5180            PRINT TABXY(Start,10);Pa_d(I)
5190            PRINT TABXY(Start,11);Pa_m(I)
5200            PRINT TABXY(Start,12);La_m(I)
5210            PRINT TABXY(Start,13);Ra_m(I)
5220            Start=Start+5
5230        NEXT I
5240        Start=15
5250        FOR I=0 TO Heart_ptr
5260            PRINT TABXY(Start,14);Heart_time$(I)
5270            PRINT TABXY(Start,15);Ci(I)
5280            PRINT TABXY(Start,16);Pvri(I)
5290            PRINT TABXY(Start,17);Svri(I)
5300            Start=Start+5
```

```
5310        NEXT I
5320        IF Pres_ptr>Pres_p THEN
5330            INPUT "more data on next page - do you
            want this dumped to printe
              r? (Y/N)",Ans$
5340            IF Ans$="Y" OR Ans$="y" THEN CALL Graph_
            dump(Out_graph)
5350            Pres_stl=13
5360            Pres_p=Pres_ptr
5370            Start=15
5380            FOR J=3 TO 13
5390            PRINT TABXY(Start,J);"            "
5400            NEXT J
5410            GOTO Pres_dp
5420        END IF
5430        GOTO Finish
5440 !
5450 !
5460 Drug:!                          ....hey man, drugs
5470       !IF Drug_ptr>9 THEN Drug_stl=4
5480       ! IF Drug_ptr>14 THEN Drug_stl=9
5490       !IF Drug_ptr>19 THEN Drug_stl=14
5500       !IF Drug_ptr>24 THEN Drug_stl=19
5510       !IF Drug_ptr>29 THEN Drug_stl=24
5520       !IF Drug_ptr>34 THEN Drug_stl=29
5530       !IF Drug_ptr>38 THEN
5540       !     DISP "do not enter more drugs; disc full"
5550      !      WAIT 3
5560      !      SUBEXIT
5570      ! END IF
5580        PRINT TABXY(30,4);"Drug Chart"
5590        PRINT TABXY(1,6);"Name"
5600        PRINT TABXY(30,6);"Dosage"
5610        PRINT TABXY(60,6);"Time"
5620        D_line=7
5630        IF Drug_ptr>9 THEN Drug_p=9
```

```
5640 Drug_dp:FOR I=Drug_stl TO Drug_p
5650            PRINT TABXY(1,D_line);Drug_name$(I)
5660            PRINT TABXY(30,D_line);Drug_dos$(I)
5670            PRINT TABXY(60,D_line);Drug_time$(I)
5680            D_line=D_line+1
5690        NEXT I
5700        IF Drug_ptr>Drug_p THEN
5710            INPUT "more data on next page - do you
            want this dumped to printer? (Y/N)",Ans$
5720            IF Ans$="Y" OR Ans$="y" THEN CALL Graph_
            dump(Out_graph)
5730            Drug_stl=Drug_stl+10
5740            Drug_p=Drug_p+10
5750            D_line=7
5760            FOR J=7 TO 17
5770                PRINT TABXY(1,J);"      "
5780            NEXT J
5790            GOTO Drug_dp
5800        END IF
5810 Finish:  !
5820   SUBEND
5830   !
5840   !
5850   !
5860   SUB Graph_dump(A)
5870 Graph_dump:INPUT "do you want a hard copy?
  <Y/N>",Ans$
5880        IF Ans$="Y" OR Ans$="y" THEN
5890            IF A=1 THEN
5900                DUMP GRAPHICS #701
5910                PRINTER IS 701
5911                PRINT CHR$(12)
5920                GRAPHICS OFF
5930            ELSE
5940                DUMP ALPHA #701
5950                PRINTER IS 701
```

```
5960                PRINT CHR$(12)
5970            END IF
5980        END IF
5990        PRINTER IS 1
6000    SUBEND
```

```
10 Hrsa3:!THIS IS A PROGRAM TO SET UP THE HIGH SPEED
A/D         !SYSTEM
20         ! AND CONTINUOUSLY OBTAIN INFORMATION
30         !
40         !
50         !..............................................
60         !
70         ! LAST REVISION: 30 April 1985
80         !
90         !..............................................

100        !
110        !
120        ! > FULL SET OF DECLARATIONS FOR THE HPIB BUS
             EXTENDED TALK ADDRESSES
130        !
140        !
150 Assignments:   !
160    ASSIGN @Multi TO 723
170    ASSIGN @Input_para TO 72301
180    ASSIGN @Input_intr TO 72302
190    ASSIGN @Input_ext TO 72303
200    ASSIGN @Read_format TO 72304
210    ASSIGN @Memory_input TO 72305
220    ASSIGN @Read_val TO 72306
230    ASSIGN @Read_status TO 72308
240    ASSIGN @Output_intr TO 72309
250    ASSIGN @Hpib_srq_status TO 72310
260    ASSIGN @Err_status_lst TO 72311
270    ASSIGN @Int_addr TO 72312
280    ASSIGN @Busy_instr TO 72313
290    ASSIGN @Read_clock TO 72314
300  !
310  !
```

```
320  !.........................................
330  !
340  ! SET UP INTERRUPT/ERROR HANDLERS
350  ! SET UP COMMON STORAGE/ARRAY STORAGE
360  !.........................................

370  !
380  !
390   COM /Intr_7/ Int_flag,Status_bytes(5)
400   COM /Flags/ Atod_done,Scanner_done,Memory1_
      done,Memory2_done,Timer_done,Counter_done,
           Memory3_done,Memory4_done
410   COM /Io_arrays/ Counters(3),Counters2(3),Time_
      base$[7]
420   COM /Multi_param/ Start_chan,Stop_chan,Pacing_
      bits,Pacing_rate,Num_pts,Nu m_xfer,Num_xfer_
           left,Name_len,Scr_file$[28],Scr_
      file2$[28]
430   COM /Hr_sig/ Num_pulses,Last_pulse,First_blk_
      flg,Last_time,Num_hr_sig,Max_hr_pts,Avg_
          hr,Rollover,Hr_smooth
440   COM /Plot_par/ Plotbox,Boxcar_flg,Log_
          plotflg,Freq_limit,Resp_search,Pct_thresh
450   COM /Graphs/
      Hrdata(512),Hrspec(512),Respspec(512),Bpspec(512)
460   COM /Vitaldata/ Rfa,Lfa,Peakratio,Meas_resp,Next_
      time
470   COM /Messagecom/ Message$(10)[80],@Messages
480   COM /Trends/ Mean_hr_t(60),Lfa_t(60),Rfa_
      t(60),Ratio_t(60),T_ptr,Time_now 1,Meas_resp_
         t(60),Trend_dp
490   COM /Pressure/
      Top1,Top2,Top3,Top4,Bot1,Bot2,Bot3,Bot4
500   COM /Editor/ Edit_msg$[80]
510   COM /Subject/ Sub_name$[25],Hos_num$[15],Id_
      age$[10],Id_wt$[10],Id_ht$[10 ],Diag$[30],
```

```
          Opera$[45],Halt_pg
520    COM /Io_chart/ Io_time$(8)[10],Iv_intake(8),Fluid_
       in(8),In_tot(8),Urine(8 ),Chest(8),Out_
            tot(8),Net(8),Io_ptr
530    COM /Lab_chart/ Lab_time$(8)[10],Na(8),Kl(8),
            Cl(8),Hco3(8),Ca(8),Hct(8),G luc(8),
            Dig(8),Pt(8),Ptt(8),Creat(8),Bun(8),Lab_ptr
540    COM /Vent_chart/ Vent_
       time$(8)[15],Rate(8),Fio2(8),Pp(8),Peep(8),Tv(8),
       Ie_ratio$(8)[10],Airp(8),Ph(8),Po2(8),
       Pco2(8),Bgo3(8),Be(8),Vent_ptr
550    COM /Pres_chart/ Pres_time$(20)[15],Ao_s(20),Ao_
       d(20),Ao_m(20),Pa_s(20),Pa_d(20),Pa_m(20),
       La_m(20),Ra_m(20),Pres_ptr,Pres_in
560    COM /Heart_index/ Heart_
       time$(15)[15],Ci(15),Pvri(15),Svri(15),Heart_ptr
570    COM /Drugs/ Drug_time$(40)[20],Drug_
       name$(40)[40],Drug_dos$(40)[20],Drug_ptr
590    DIM Io$(5,15)[30],Io_msg$(5,15)[80]
600    DIM Msg_pad$(10)[80]
610    DIM Msg_buffer$[80] BUFFER
620    ASSIGN @Msg_buffer TO BUFFER Msg_buffer$
630    Log_plotflg=0
640    Freq_limit=1.
650    Resp_search=.1
660    Pct_thresh=.2
670    Scr_file$="?"
680    Halt_pg=0
690    Message$(0)="messages in "
700    Message$(1)="I/O chart "
710    Message$(2)="lab values"
720    Message$(3)="hemodynamics"
730    Message$(4)="Trends Display"
740    Message$(5)="messages out"
750    Message$(6)="STOP PROGRAM"
760    Message$(7)="ventilation"
```

```
770   Message$(8)="drugs"
780   Message$(9)="B.P. Display"
790   Msg_pad_ptr=0
800   P_ptr=0
810  !
820  ! Set up common/array storage for waveform
       analysis
830  !
840  !.............................................
850  !
860  ! Set up common/array storage for waveform
          analysis
870  !.............................................

880  !
890   COM /Directory/ Dir$[160],@Printer
900   COM /Wf1/ Printer,Plotter,String$[40]
910   COM /Wf2/ Signal(1089),Number_pnts,Type,Sampling_
        period
920   COM /Wf3/ Segment_size,Overlap,Num_segments,Pnts_
        used,Fft_size
930   COM /Wf5/ Refn(63),Refd(63),Refno,Refdo,Refgain
940   COM /Autoparam/ Up_down,Up_delay,Dn_delay
950   COM /Vars/ Ffthrvar,Fftrespvar
960  !
970   DISP "loading subroutines"
980   LOADSUB ALL FROM "multi_subs"
990   LOADSUB ALL FROM "hr_siggen8"
1000  LOADSUB ALL FROM "automaxsb2"
1010  LOADSUB ALL FROM "fft_anal6"
1020  DISP "load data disks and press CONTINUE"
1030  PAUSE
1040 !
1050 !............................................
1060 ! The HP 9826/9836 flexible disk (5-1/4") has the
     ! following structure
```

```
1070  !  2 sides, 33 tracks/side, 16 sectors/track, 256
      !  bytes/sector
1080  !   1 track =   4096 bytes =   16 sectors
1090  !   1 side  = 135168 bytes =  528 sectors
1100  !   1 disk  = 270336 bytes = 1056 sectors
1110  !   1 disk  = 135168 words = 132K words
1120  !.................................................

1130  !
1140  !
1150   INTEGER Hpib_buffer1(2048) BUFFER
1160   INTEGER Hpib_buffer2(2048) BUFFER
1170   DIM Hr_signal(1024) BUFFER
1180   Read_ptr1=0
1190   Read_ptr2=0
1200  !
1210  !
1220  !...............................................
1230  ! CLEAR MULTIPROGRAMMER
1240  !................................................

1250  !
1260  !
1270   ON INTR 7 CALL Hpib_intr
1280 Begin:CALL Multi_clear
1290  !
1300  !
1310  !...............................................
1320  ! LOAD SUPPLEMENTAL INSTRUCTION SET ("MR")
1330  ! usage: "MR,<card addr>,<# words>,<read
ptr>,<mode>T"
1340  !          <mode= 1-FIFO, 4-recirculating>
1350  !.............................................

1360  !
1370  !
```

```
1380  DISP "DOWNLOADING MR INSTRUCTION"
1390  CALL Xfer("MR")
1400  !
1410  !
1420  !.........................................
1430  ! SET UP CARDS FOR DATA COLLECTION
1440  !.........................................

1450  !
1460  !
1470 Selections:DISP "SETUP DATA COLLECTION"
1480  OUTPUT @Multi;"CY,3T"!CYCLE SCAN/PACER CARD TO
      SET DEFINITE STATE
1490  !
1500  !
1510  ! NOW SET UP THE SCAN CARD PARAMETERS (DEFAULT
      ! VALUES)
1520  !     START CHANNEL (3.0) -  0
1530  !      STOP CHANNEL (3.1) -  1
1540  !           PACING (3.2) - 40 USEC
1550  !       SEQN'L SCAN (3.3) - XXXX XXXX XXX1 (  1)
1560  !     INTN'L PACING (3.3) - XXXX XXXX X1XX (  4)
1570  !     MSEC TIMEBASE (3.3) - XXX1 XXXX XXXX (256)
1580  !
1590  CALL Get_param
1600  ASSIGN @Messages TO
      "messglog:HP8290X,700,1";FORMAT OFF
1610  ASSIGN @Temp_trend TO "temp_
      trend:HP8290X,700,1";FORMAT OFF
1620  ASSIGN @Hemo_data TO "hemo_
      data:HP8290X,700,1";FORMAT OFF
1630  ASSIGN @Io_data TO "io_data:HP8290X,700,1";FORMAT
      OFF
1640  ASSIGN @Lab_data TO "lab_
      data:HP8290X,700,1";FORMAT OFF
1650  ASSIGN @Vent_data TO "vent_
```

```
data:HP8290X,700,1";FORMAT OFF
1660   ASSIGN @Co_data TO "co_data:HP8290X,700,1";FORMAT
OFF
1670   ASSIGN @Drug_data TO "drug_
data:HP8290X,700,1";FORMAT OFF
1680   IF Num_pts=0 THEN GOTO Begin
1690   Read_ptr1=0
1700  !
1710  !
1720  ! SET FIFO MODE AND CLEAR POINTERS IN MEMORY
1730  !
1740   !
1750 Setup_scan:DISP " NUMBER OF POINTS=";Num_pts
1760   OUTPUT @Multi;"WF,3.0",Start_chan,"3.1",Stop_
       chan,"3.3",Pacing_bits,"3.2"
         ,Pacing_rate,"T"
1770   OUTPUT @Multi;"CC,6T"
1780   OUTPUT @Multi;"WF,5.1,1,T" ! memory set to FIFO
       input mode
1790   OUTPUT @Multi;"AC,3,5,6T"  ! cards are armed to
       supply interrupts
1800   OUTPUT @Multi;"RV,6.0,6.1,6.2,6.3T" ! checking
       control registers
1810   ENTER @Read_val;Counters(*)
1820   Read_ptr1=0
1830   Read_ptr2=0
1840  !
1850  ! setup the counter card to count
1860  !
1870 Setup_counter:OUTPUT @Multi;"CC,10,11,12,13T"
1880   OUTPUT @Multi;"AC,10,12,13T" !_counter not armed
1890   OUTPUT @Multi;"CY,11T"
1900  !
1910  ! setup the pacer card to generate a clock with
        period 32 Usec
1920  !      (one half period is 16 Usec)
```

```
1930 !      (corresponds to 31.25KHz)
1940 !
1950 Setup_clock:OUTPUT @Multi;"WF10.2,1T"
1960  OUTPUT @Multi;"WF10,16U T"
1970  CALL Completer("setup completed")
1980 !
1990 !
2000 ! START THE PACERS BY CYCLING IN PARALLEL
2010 !
2020  OUTPUT @Multi;"GPT"
2030  CALL Init_flags
2040  ENABLE INTR 7;2
2050  OUTPUT @Multi;"CY,3,10T"
2060  OUTPUT @Multi;"GST"
2070  Start_pacing=TIMEDATE
2080  CALL Completer("PACING STARTED")
2090  Block_time=Pacing_rate*1.024
2100  Next_time=TIMEDATE+INT(Block_time)
2110  First_blk_flg=1
2120  Num_msgs=0
2130  Message_line=0
2140  Msg_dp_request=0
2150  Resp_dpflg=0
2160  Max_hr_pts=1024
2170  Last_time=0
2180  Trend_dp=0
2190 !Hemo_dp=0
2200  Top1=0
2210  Top2=0
2220  Top3=0
2230  Top4=0
2240  Bot1=0
2250  Bot2=0
2260  Bot3=0
2270  Bot4=0
2280 !
```

```
2290   Io$(1,1)="Time - hh:mm(hh=1 to 24)"
2300   Io$(1,2)="Maint. fluids"
2310   Io$(1,3)="other fluids"
2320   Io$(1,4)="urine output"
2330   Io$(1,5)="chest output"
2340   Io$(2,1)="Time - hh:mm"
2350   Io$(2,2)="Na"
2360   Io$(2,3)="K"
2370   Io$(2,4)="Cl"
2380   Io$(2,5)="HCO3"
2390   Io$(2,6)="Ca"
2400   Io$(2,7)="Hct"
2410   Io$(2,8)="Glucose"
2420   Io$(2,9)="Dig level"
2430   Io$(2,10)="PT"
2440   Io$(2,11)="PTT"
2450   Io$(2,12)="Creat"
2460   Io$(2,13)="Bun"
2470   Io$(3,1)="Time - hh:mm(hh=1 to 24)"
2480   Io$(3,2)="Resp rate"
2490   Io$(3,3)="FIO2"
2500   Io$(3,4)="Peak pres"
2510   Io$(3,5)="peep"
2520   Io$(3,6)="TV"
2530   Io$(3,7)="I:E"
2540   Io$(3,8)="mean airway"
2550   Io$(3,9)="ph"
2560   Io$(3,10)="pO2"
2570   Io$(3,11)="pCO2"
2580   Io$(3,12)="HCO3"
2590   Io$(3,13)="BE"
2600   Io$(4,1)="Time - hh:mm(hh=1 to 24)"
2610   Io$(4,2)="ao/s"
2620   Io$(4,3)="ao/d"
2630   Io$(4,4)="ao/m"
2640   Io$(4,5)="pa/s"
```

```
2650   Io$(4,6)="pa/d"
2660   Io$(4,7)="pa/m"
2670   Io$(4,8)="la/m"
2680   Io$(4,9)="ra/m"
2690   Io$(4,10)="Time - hh:mm(hh=1 to 24)"
2700   Io$(4,11)="C.I."
2710   Io$(4,12)="pvri"
2720   Io$(4,13)="svri"
2730   Io$(5,1)="name"
2740   Io$(5,2)="dosage"
2750   Io$(5,3)="Time - hh:mm:ss(hh=1 to 24)"
2760   Io_ptr=0
2770   Lab_ptr=0
2780   Vent_ptr=0
2790   Pres_ptr=0
2800   Heart_ptr=0
2810   Drug_ptr=0
2820   Io_in=0
2830   Lab_in=0
2840   Vent_in=0
2850   Pres_in=0
2860   Heart_in=0
2870   Drug_in=0
2880   Fst=1
2890   Fix_val=0
2900  !
2910  ! Read data continuously and write to the disk
        continuously until enough
2920  ! enough data has been obtained
2930  !
2940  !
2950 Reading:  !
2960  !
2970  ! set up the A/D buffers and disk files
2980  !
2990   ASSIGN @Memory_input TO 72305;FORMAT OFF
```

```
3000  ASSIGN @In_buffer TO BUFFER Hpib_buffer1(*)
3010  ASSIGN @Out_buffer TO Scr_file$;FORMAT OFF
3020 !
3030 ! set up the counter memory buffers and files
3040 !
3050  ASSIGN @Memory_input2 TO 72305;FORMAT OFF
3060  ASSIGN @In_buffer2 TO BUFFER Hpib_buffer2(*)
3070  ASSIGN @Out_buffer2 TO Scr_file2$;FORMAT OFF
3080 !
3090  Data_lockout=0
3100 !
3110  Time_now=TIMEDATE
3120  Date_now$=DATE$(TIMEDATE)
3130  Time_now1=Time_now MOD 86400
3140 !
3150 Blk_xfer:!
3160  CONTROL @In_buffer,3;1
     ! Reset fill pointer for buffer
3170  CONTROL @In_buffer,4;0
     ! Reset current number of bytes in buffer
3180  CONTROL @In_buffer,5;1      ! Reset empty pointer
      for buffer
3190 !
3200 ! write an 8 byte sequence to disk as a header for
     ! the transfer
3210 !
3220  CALL Xfheader(@Out_buffer,Num_pts,"R")
3230 !
3240 ! read A/D buffer into memory (hpib_buffer1) in 32
       segments
3250 ! if possible
3260 !
3270  IF FRACT(Num_pts/32.)=0 THEN
3280      Num_rdseg=32
3290      Num_rdpts=Num_pts/32
3300  ELSE
```

```
3310          Num_rdseg=1
3320          Num_rdpts=Num_pts
3330      END IF
3340     !
3350     ! reading segments here. segmenting allows disk
           access between segments
3360     !
3370      FOR Rdseg=1 TO Num_rdseg
3380          OUTPUT @Multi;"MR,5",Num_rdpts,Read_
              ptrl,"1T"! FIFO mode
3390          ON EOT @Memory_input GOTO Next_rdseg
3400          TRANSFER @Memory_input TO @In_buffer;COUNT
              Num_rdpts*2,CONT
3410          PRINT TABXY(1,18);
3420          PRINT USING Image_wtl;Num_xfer-Num_xfer_
              left+1,Num_xfer,TIME$(Next_time),
                 Rdseg,Num_rdseg
3430 Image_wtl:IMAGE    "Next xfer(",K,"/",K,"): ",K,"
     seg=",K,"/",K
3440 Waiter1:DISP "Now: ";TIME$(TIMEDATE);"
     ";DATE$(TIMEDATE)
3450          IF Next_time-TIMEDATE<12 THEN
3460              OFF KEY
3470              OFF KBD
3480              OFF KNOB
3490              GOTO Waiter1
3500          END IF
3510          ON KEY 0 LABEL Message$(0) GOSUB Key0
3520          ON KEY 1 LABEL Message$(1) GOSUB Key1
3530          ON KEY 2 LABEL Message$(2) GOSUB Key2
3540          ON KEY 3 LABEL Message$(3) GOSUB Key3
3550          ON KEY 4 LABEL Message$(4) GOSUB Key4
3560          ON KEY 5 LABEL Message$(5) GOSUB Key5
3570          ON KEY 6 LABEL Message$(6) GOSUB Key6
3580          ON KEY 7 LABEL Message$(7) GOSUB Key7
3590          ON KEY 8 LABEL Message$(8) GOSUB Key8
```

```
3600        ON KEY 9 LABEL Message$(9) GOSUB Key9
3610        ON KBD GOTO Control_chars
3620        IF Msg_dp_request=2 THEN
3630            ON KNOB .05 GOSUB Move_msgs
3640        ELSE
3650            OFF KNOB
3660        END IF
3670        STATUS @In_buffer,10;In_xfer_stat
3680        IF In_xfer_stat<64 THEN GOTO Next_rdseg
3690        IF Msg_dp_request=3 THEN
3700            CALL Msg_dump(Message_chart$(*),Message_
                line,Msg_dp_request)
3710        END IF
3720        GOTO Waiter1
3730 Control_chars:!
3740        Kbd_hold$=KBD$
3741        IF POS(Kbd_hold$,CHR$(6))<>0 THEN
      !..change lfa disp.range
3742           Lfa_top=Lfa_top+2.5
3750        IF POS(Kbd_hold$,CHR$(6))<>0 THEN
      !..change spectra disp.freq.range
3760            IF Freq_limit=1. THEN
3770                Freq_limit=2.
3780            ELSE
3790                Freq_limit=1.
3800            END IF
3810            Resp_search=.1
     !..reset resp search point each time
3820            DISP "Spectra displayed to";Freq_
                  limit;"Hz"
3830            WAIT 2
3840        END IF
3850        IF POS(Kbd_hold$,CHR$(8))<>0 THEN  !..help:
            display commands
3860            CALL Disp_ctrls
3870        END IF
```

```
3880        IF POS(Kbd_hold$,CHR$(16))<>0 THEN
     !..change peak search threshold
3890            Pct_thresh=Pct_thresh+.2
3900            IF Pct_thresh>.8 THEN Pct_thresh=.2
3910            DISP "resp peak search threshold=";Pct_
                thresh;"%"
3920            WAIT 1
3930        END IF
3940        IF POS(Kbd_hold$,CHR$(18))<>0 THEN
      !..display respiration time series
3950            IF Resp_dpflg=0 THEN
3960                Resp_dpflg=1
3970                DISP "resp series plot w/hr series"
3980                WAIT 2
3990            ELSE
4000                Resp_dpflg=0
4010                DISP "cancel resp series plot"
4020                WAIT 2
4030            END IF
4040        END IF
4050        IF POS(Kbd_hold$,CHR$(19))<>0 THEN
     !..change respiration peak search
4060            Resp_search=Resp_search+.1
4070            IF Resp_search>Freq_limit-.1 THEN Resp_
                search=.1
4080            DISP "resp peak search starts at";Resp_
                search;"Hz"
4090            WAIT 1
4100        END IF
4110        GOTO Waiter1
4120 Next_rdseg:!
4130 !
4140 ! storing messages from soft keys if any
4150 !
4160        IF Msg_pad_ptr>0 THEN
4170            Num_msgs=Num_msgs+Msg_pad_ptr
```

```
4180          FOR I=0 TO Msg_pad_ptr-1
4190              Msg_buffer$=Msg_pad$(I)
4200              Len_message=LEN(Msg_buffer$)
4210              CONTROL @Msg_buffer,4;Len_
                  message       !....number of bytes
4220              CONTROL @Msg_buffer,5;1
      !..empty pointer to beginning
4230              TRANSFER @Msg_buffer TO
                  @Messages;COUNT Len_message,CONT
4240          NEXT I
4250          IF Msg_dp_request>=2 THEN
4260              DEALLOCATE Message_chart$(*)
4270              Msg_dp_request=0
4280          END IF
4290          OFF KNOB
4300          Msg_pad_ptr=0
4310      END IF
4320      IF Msg_dp_request=1 THEN
4330          Message_line=0
4340          ALLOCATE Message_chart$(17)[640]
4350          CALL Msg_dump(Message_chart$(*),Message_
              line,Msg_dp_request)
4360          IF Msg_dp_request=0 THEN
      !...no messages
              yet
4370              DEALLOCATE Message_chart$(*)
4380          END IF
4390      END IF
4400  !
4410  ! get read pointer for next segment
4420  !
4430      OUTPUT @Multi;"RV,6.0T"
      !   checking current read pointer
4440      ENTER @Read_val;Read_ptr1
4450   NEXT Rdseg
4460  !
```

```
4470  ! store A/D buffer on complete data file (also
        save pointers for heart rate)
4480  !
4490  !
4500 Resume1:OFF EOT @Memory_input
4510   OFF KEY
4520   OFF KBD
4530   OFF KNOB
4540   IF Msg_dp_request>=2 THEN
4550       DEALLOCATE Message_chart$(*)
4560       Msg_dp_request=0
4570   END IF
4580   IF Trend_dp=1 OR Trend_dp=2 THEN DEALLOCATE
       Spectra(*)
4590   Next_time=Next_time+INT(Block_time)
4600   ON EOT @Out_buffer GOTO Resume2
4610   OUTPUT @Multi;"RV,13.0,13.1,13.2,13.3T"
      ! checking control registers
4620   ENTER @Read_val;Counters2(*)
4630   Read_ptr2=Counters2(0)
4640   Num_pulses=Counters2(1)
4650   TRANSFER @In_buffer TO @Out_buffer;COUNT Num_
       pts*2,CONT
4660 Waiter2:DISP TIME$(TIMEDATE),DATE$(TIMEDATE)
4670   GOTO Waiter2
4680  !
4690  !
4700  !
4710  !
4720 Resume2:OFF EOT @Out_buffer
4730   Num_xfer_left=Num_xfer_left-1
4740    OUTPUT @Multi;"MR,12",Num_pulses,Read_
        ptr2,"1T"          ! FIFO mode
4750    CONTROL @In_buffer2,3;1
      ! Reset fill pointer for buffer
4760    CONTROL @In_buffer2,4;0
```

```
           ! Reset current number of bytes in buffer
4770         CONTROL @In_buffer2,5;1
           ! Reset empty pointer for buffer
4780   !
4790   ! write an 8 byte sequence to disk as a header for
       ! the transfer
4800   !
4810    CALL Xfheader(@Out_buffer2,Num_pulses,"H")
4820   !
4830   ! read multiprogrammer into computer memory (hpib_
         buffer)
4840   !
4850    ON EOT @Memory_input2 GOTO Resume4
4860    TRANSFER @Memory_input2 TO @In_buffer2;COUNT Num_
        pulses*2,CONT
4870 Waiter4:DISP TIME$(TIMEDATE),DATE$(TIMEDATE)
4880    GOTO Waiter4
4890   !
4900   ! store computer memory on complete data file
4910   !
4920 Resume4:OFF EOT @Memory_input2
4930    ON EOT @Out_buffer2 GOTO Resume5
4940    TRANSFER @In_buffer2 TO @Out_buffer2;COUNT Num_
        pulses*2,CONT
4950 Waiter5:DISP TIME$(TIMEDATE),DATE$(TIMEDATE)
4960    GOTO Waiter5
4970   !
4980 Resume5:OFF EOT @Out_buffer2
4990    CALL Hr_sig_gen(Hpib_buffer2(*),Hr_signal(*))
5000   !


5010   !
5020 Resume6:!
5030    OUTPUT @Multi;"RV,6.0,6.1,6.2,6.3T"
      ! checking control registers
```

```
5040   ENTER @Read_val;Counters(*)
5050   Read_ptr1=Counters(0)
5060   IF Counters(1)=4095 THEN ! Data lockout probably occurred
5070      PRINT "DATA LOCKOUT!! TIME RECORD NOT CONTINUOUS!!"
5080      PRINT "ABORTING CURRENT DATA COLLECTION."
5090      Data_lockout=1
5100      Num_xfer_left=0
5110   END IF
5120   OUTPUT 2;CHR$(255)&CHR$(75);  ! Clear CRT of text
5130   GINIT
5140   PLOTTER IS 3,"INTERNAL"
5150   GRAPHICS ON
5160   Xscale=8
5170   Hr_max=MAX(Hr_signal(*))
5180   Hr_min=MIN(Hr_signal(*))
5190   VIEWPORT 0,64,50,100
5200   WINDOW 0,1,0,1
5210   AXES .1,.1,0,0
5220   CSIZE 4
5230   Hr_signal(1024)=0
5240   Hr_sigsum=SUM(Hr_signal)
5250   Mean_hr=INT((Hr_sigsum/1024+Avg_hr))
5260   Hr_bias=Hr_sigsum/1024
5270   LDIR 0
5280   LORG 3
5290   MOVE .2,.9
5300   LABEL "HR data   hr=";Mean_hr
5310   CSIZE 4
5320   MOVE .05,1
5330   LORG 3
5340   LABEL "250 bpm"
5350   WINDOW 1,0,1,0
5360   AXES 0,0,0,0
```

```
5370  IF Hr_dispflg=1 THEN
5380      WINDOW 0,1024,Hr_min,Hr_max
5390  ELSE
5400      Low_window=INT(-Avg_hr)
5410      High_window=Low_window+250.
5420      WINDOW 0,1024,Low_window,High_window
5430  END IF
5440  FOR I=0 TO 1023
5450      PLOT I,Hr_signal(I)
5460  NEXT I
5470  !
5480  ! display respirations time series also
5490  !
5500  IF Resp_dpflg=1 THEN
5510      Max_resp=MAX(Hpib_buffer1(*))
5520      Min_resp=MIN(Hpib_buffer1(*))
5530      IF Mean_hr>100 THEN
5540          VIEWPORT 0,64,50,65
5550      ELSE
5560          VIEWPORT 0,64,75,90
5570      END IF
5580      WINDOW 0,1023,Min_resp,Max_resp
5590      MOVE 0,Hpib_buffer1(0)
5600      FOR I=1 TO 1023
5610          PLOT I,Hpib_buffer1(I)
5620      NEXT I
5630  ELSE
5640      Resp_dpflg=0
5650  END IF
5660  !
5670  ! now process heart rate data with waveform
        analysis package
5680  ! make sure the hr_signal has zero mean
5690  !
5700  FOR I=0 TO 1023
5710      Signal(I)=Hr_signal(I)-Hr_bias
```

```
5720  NEXT I
5730  Plotbox=2
5740  DISP "HR fft in process"
5750  CALL Wf_analyzer(Pacing_rate)
5760  !
5770  ! now process respiration data with waveform
       analysis package
5780  !
5790  MAT Signal= (0)
5800  FOR I=0 TO 1023
5810      Signal(I)=Hpib_buffer1(I)
5820  NEXT I
5830  Signal_avg=SUM(Signal)/1024.
5840  MAT Signal= Signal-(Signal_avg)
5850  Plotbox=4
5860  DISP "RESP fft in process"
5870  CALL Wf_analyzer(Pacing_rate)
5880  Trend_dp=0 !..trend graph not displayed
5890  !
5900  ! waveform analysis completed, compile trends and
       store in temporary file
5910  !
5920  Mean_hr_t(T_ptr)=Mean_hr
5930  Lfa_t(T_ptr)=Lfa
5940  Rfa_t(T_ptr)=Rfa
5950  Ratio_t(T_ptr)=Peakratio
5960  Meas_resp_t(T_ptr)=Meas_resp
5961  Trans_time(T_ptr)=Xfer_time
5970  T_ptr=T_ptr+1
5980  OUTPUT @Temp_trend;T_ptr-1,Mean_
      hr,Lfa,Rfa,Peakratio,Meas_resp,Xfer_time
5990  IF Pres_in=1 THEN
6000      Pr=Pres_ptr-1
6010      OUTPUT @Hemo_data;Pres_time$(Pr),Ao_s(Pr),Ao_
          d(Pr),Ao_m(Pr),Pa_s(Pr),
            Pa_d(Pr),Pa_m(Pr),La_m(Pr),Ra_m(Pr),Pr
```

```
6020        Pres_in=0
6030    END IF
6040    IF Io_in=1 THEN
6050        Io=Io_ptr-1
6060        OUTPUT @Io_data;Io_time$(Io),Iv_
            intake(Io),Fluid_in(Io),In_tot(Io),Ur
             ine(Io),Chest(Io),Out_tot(Io),Net(Io),Io
6070        Io_in=0
6080    END IF
6090    IF Lab_in=1 THEN
6100        L=Lab_ptr-1
6110        OUTPUT @Lab_data;Lab_
time$(L),Na(L),Kl(L),Cl(L),Hco3(L),Ca(L),Hct(L),
Gluc(L),Dig(L),Pt(L),Ptt(L),Creat(L),Bun(L),L
6120        Lab_in=0
6130    END IF
6140    IF Heart_in=1 THEN
6150        H=Heart_ptr-1
6160        OUTPUT @Co_data;Heart_
            time$(H),Ci(H),Pvri(H),Svri(H),H
6170        Heart_in=0
6180    END IF
6190    IF Vent_in=1 THEN
6200        V=Vent_ptr-1
6210        OUTPUT @Vent_data;Vent_
            time$(V),Rate(V),Fio2(V),Pp(V),Peep(V),Tv(V),
            Ie_ratio$(V),Airp(V),Ph(V),Po2(V),Pco2(V),
             Bgo3(V),Be(V),V
6220        Vent_in=0
6230    END IF
6240    IF Drug_in=1 THEN
6250        D=Drug_ptr-1
6260        OUTPUT @Drug_data;Drug_time$(D),Drug_
            name$(D),Drug_dos$(D),D
6270        Drug_in=0
6280    END IF
```

```
6290  !
6300  ! continue with data collection
6310  !
6320   IF Num_xfer_left<=0 THEN
6330       Halt_pg=1
6340       GOTO Eo_blk_xfer
6350   ELSE
6360       DISP Num_xfer_left;"transfers remaining"
6370       WAIT 3
6380       GOTO Blk_xfer
6390   END IF
6400 Eo_blk_xfer:End_time=TIMEDATE
6410   Delta_time=End_time-Start_time
6420   !
6430   OUTPUT @Multi;"WF,3.2,0T"
6440   Stop_pacing=TIMEDATE
6450 !
6460 Aborter:!
6470   ASSIGN @In_buffer TO *
6480   ASSIGN @In_buffer2 TO *
6490   ASSIGN @Out_buffer TO *
6500   ASSIGN @Out_buffer2 TO *
6510   ASSIGN @Messages TO *
6520   ASSIGN @Temp_trend TO *
6530   ASSIGN @Hemo_data TO *
6540   ASSIGN @Io_data TO *
6550   ASSIGN @Lab_data TO *
6560   ASSIGN @Vent_data TO *
6570   ASSIGN @Co_data TO *
6580   ASSIGN @Drug_data TO *
6590   OUTPUT @Multi;"CC,3,5,6,10,11,12,13T"
6600   OUTPUT @Multi;"CC,5T"
6610   CALL Completer("READY TO RESTART")
6620   CALL Pauser
6630   GRAPHICS OFF
6640   CALL Get_param
```

```
6650   ASSIGN @Messages TO
          "messglog:HP8290X,700,1";FORMAT OFF
6660   IF Num_pts=0 THEN GOTO Begin
6670   GOTO Setup_scan
6680 Diag:OUTPUT 723;"RV,3.0,3.3T"
6690   ENTER 72306;C,C0
6700   PRINT "CURRENT/START CHANNEL";C,C0
6710   OUTPUT 723;"RV,6.0,6.1,6.2,6.3T"
     ! checking control registers
6720   ENTER 72306;Counters(*)
6730   PRINT "COUNTERS=";Counters(*)
6740   STOP
6750 Purger:!
6760   GRAPHICS OFF
6770   DELSUB Hpib_intr TO END
6780   PURGE "AOK:HP8290X,700,1"
6790   PURGE "hrAOK:HP8290X,700,1"
6800   PURGE "messglog:HP8290X,700,1"
6810   PURGE "temp_trend:HP8290X,700,1"
6820   PURGE "hemo_data:HP8290X,700,1"
6830   PURGE "co_data:HP8290X,700,1"
6840   PURGE "vent_data:HP8290X,700,1"
6850   PURGE "lab_data:HP8290X,700,1"
6860   PURGE "drug_data:HP8290X,700,1"
6870   PURGE "io_data:HP8290X,700,1"
6871   PURGE "sub_data:HP8290X,700,1"
6880   STOP
6890 !
6900 ! definitions for keys
6910 !
6920 Move_msgs:! knob is processed here
6930   IF Msg_dp_request<>2 THEN RETURN
6940   Message_line=Message_line+KNOBX
6950   IF Message_line>Num_msgs-3 THEN Message_line=Num_
       msgs-3
6960   IF Message_line<0 THEN Message_line=0
```

```
6970   Msg_dp_request=3
6980   RETURN
6990   !
7000   !
7010 Key0:Key_id=0
7020   Edit_msg$=""
7030   CALL Editor
7040 Key_msg:Msg_pad$(Msg_pad_
       ptr)="Time:"&TIME$(TIMEDATE)&" "&Edit_msg$
7050   Msg_pad_ptr=Msg_pad_ptr+1
7060   DISP "only";10-Msg_pad_ptr;"more messages during
       this segment"
7070   PRINT TABXY(1,18);"
                                    "
7080   PRINT TABXY(1,18);Edit_msg$
7090   WAIT 3
7100   PRINT TABXY(1,18);"
                                    "
7110   PRINT TABXY(1,18);"Next transfer: ";TIME$(Next_
       time)
7120   GOTO Keyend
7130   !
7140   !
7150   !
7160 Key1:Chart_num=1
       !...input/output charting
7170   IF Next_time-TIMEDATE<45 THEN
7180       DISP "not enough time to enter data; wait for
           next xfer"
7190       WAIT 2
7200       GOTO Keyend
7210   END IF
7220   GRAPHICS OFF
7230   PRINT CHR$(12)
7240   Num_var=5
7250   IF Io_in=1 THEN
```

```
7260          DISP "data in for this xfer; chart displayed"
7270          WAIT 2
7280          Io_ptr=Io_ptr-1
7290          CALL Chart(Chart_num)
7300          Io_ptr=Io_ptr+1
7310          GOTO Keyend
7320      ELSE
7330          INPUT "Input values=1 or display
              chart=2?",Inp
7340          IF Inp=1 THEN
7350              IF Io_ptr>5 THEN
7360                  DISP "Do not enter more I/O data;
                  disc full"
7370                  WAIT 3
7380                  GOTO Keyend
7390              ELSE
7400                  GOTO I_o
7410              END IF
7420          ELSE
7430              CALL Chart(Chart_num)
7440              GOTO Keyend
7450          END IF
7460      END IF
7470 Data1:!
7480      Io_time$(Io_ptr)=Io_msg$(Chart_num,1)
7490      Iv_intake(Io_ptr)=FNLval(Io_msg$(Chart_num,2))
7500      IF Iv_intake(Io_ptr)=9999.999 THEN
7510          Ionum=2
7520          Fix_val=1
7530          GOTO Data_edit
7540      END IF
7550      Fluid_in(Io_ptr)=FNLval(Io_msg$(Chart_num,3))
7560      IF Fluid_in(Io_ptr)=9999.999 THEN
7570          Ionum=3
7580          Fix_val=1
7590          GOTO Data_edit
```

```
7600    END IF
7610    Urine(Io_ptr)=FNLval(Io_msg$(Chart_num,4))
7620    IF Urine(Io_ptr)=9999.999 THEN
7630        Ionum=4
7640        Fix_val=1
7650        GOTO Data_edit
7660    END IF
7670    Chest(Io_ptr)=FNLval(Io_msg$(Chart_num,5))
7680    IF Chest(Io_ptr)=9999.999 THEN
7690        Ionum=5
7700        Fix_val=1
7710        GOTO Data_edit
7720    END IF
7730    In_tot(Io_ptr)=Iv_intake(Io_ptr)+Fluid_in(Io_ptr)
7740    Out_tot(Io_ptr)=Urine(Io_ptr)+Chest(Io_ptr)
7750    Net(Io_ptr)=In_tot(Io_ptr)-Out_tot(Io_ptr)
7760    CALL Chart(Chart_num)
7770    Io_ptr=Io_ptr+1
7780    Io_in=1
7790    Fix_val=0
7800    GOTO Keyend
7810    !
7820    !
7830 Key2:Chart_num=2
        !...ventilation charting
7840    GRAPHICS OFF
7850    PRINT CHR$(12)
7860    IF Next_time-TIMEDATE<45 THEN
7870        DISP "not enough time to enter data; wait for
            next xfer"
7880        WAIT 2
7890        GOTO Keyend
7900    END IF
7910    Num_var=13
7920    IF Lab_in=1 THEN
7930        DISP "data in for this xfer; chart displayed"
```

```
7940        WAIT 2
7950        Lab_ptr=Lab_ptr-1
7960        CALL Chart(Chart_num)
7970        Lab_ptr=Lab_ptr+1
7980        GOTO Keyend
7990   -ELSE
8000        INPUT "Input values=1 or display
            chart=2?",Inp
8010        IF Inp=1 THEN
8020            IF Lab_ptr>7 THEN
8030                DISP "Do not enter more Lab data;
                    disc full"
8040                WAIT 3
8050                GOTO Keyend
8060            ELSE
8070                GOTO I_o
8080            END IF
8090        ELSE
8100            CALL Chart(Chart_num)
8110            GOTO Keyend
8120        END IF
8130    END IF
8140 Data2:!
8150    Lab_time$(Lab_ptr)=Io_msg$(Chart_num,1)
8160    Na(Lab_ptr)=FNLval(Io_msg$(Chart_num,2))
8170    IF Na(Lab_ptr)=9999.999 THEN
8180        Ionum=2
8190        Fix_val=1
8200        GOTO Data_edit
8210    END IF
8220    Kl(Lab_ptr)=FNLval(Io_msg$(Chart_num,3))
8230    IF Kl(Lab_ptr)=9999.999 THEN
8240        Ionum=3
8250        Fix_val=1
8260        GOTO Data_edit
8270    END IF
```

```
8280   Cl(Lab_ptr)=FNLval(Io_msg$(Chart_num,4))
8290   IF Cl(Lab_ptr)=9999.999 THEN
8300       Ionum=4
8310       Fix_val=1
8320       GOTO Data_edit
8330   END IF
8340   Hco3(Lab_ptr)=FNLval(Io_msg$(Chart_num,5))
8350   IF Hco3(Lab_ptr)=9999.999 THEN
8360       Ionum=5
8370       Fix_val=1
8380       GOTO Data_edit
8390   END IF
8400   Ca(Lab_ptr)=FNLval(Io_msg$(Chart_num,6))
8410   IF Ca(Lab_ptr)=9999.999 THEN
8420       Ionum=6
8430       Fix_val=1
8440       GOTO Data_edit
8450   END IF
8460   Hct(Lab_ptr)=FNLval(Io_msg$(Chart_num,7))
8470   IF Hct(Lab_ptr)=9999.999 THEN
8480       Ionum=7
8490       Fix_val=1
8500       GOTO Data_edit
8510   END IF
8520   Gluc(Lab_ptr)=FNLval(Io_msg$(Chart_num,8))
8530   IF Gluc(Lab_ptr)=9999.999 THEN
8540       Ionum=8
8550       Fix_val=1
8560       GOTO Data_edit
8570   END IF
8580   Dig(Lab_ptr)=FNLval(Io_msg$(Chart_num,9))
8590   IF Dig(Lab_ptr)=9999.999 THEN
8600       Ionum=9
8610       Fix_val=1
8620       GOTO Data_edit
8630   END IF
```

```
8640    Pt(Lab_ptr)=FNLval(Io_msg$(Chart_num,10))
8650    IF Pt(Lab_ptr)=9999.999 THEN
8660        Ionum=10
8670        Fix_val=1
8680        GOTO Data_edit
8690    END IF
8700    Ptt(Lab_ptr)=FNLval(Io_msg$(Chart_num,11))
8710    IF Ptt(Lab_ptr)=9999.999 THEN
8720        Ionum=11
8730        Fix_val=1
8740        GOTO Data_edit
8750    END IF
8760    Creat(Lab_ptr)=FNLval(Io_msg$(Chart_num,12))
8770    IF Creat(Lab_ptr)=9999.999 THEN
8780        Ionum=12
8790        Fix_val=1
8800        GOTO Data_edit
8810    END IF
8820    Bun(Lab_ptr)=FNLval(Io_msg$(Chart_num,13))
8830    IF Bun(Lab_ptr)=9999.999 THEN
8840        Ionum=13
8850        Fix_val=1
8860        GOTO Data_edit
8870    END IF
8880    CALL Chart(Chart_num)
8890    Lab_ptr=Lab_ptr+1
8900    Lab_in=1
8910    Fix_val=0
8920    GOTO Keyend
8930    !
8940    !
8950 Key3:Chart_num=4
        !...hemodynamic graphics
8960    IF Next_time-TIMEDATE<45 THEN
8970        DISP "not enough time to enter data; wait for
            next xfer"
```

```
8980        WAIT 2
8990        GOTO Keyend
9000    END IF

9010    GRAPHICS OFF
9020    PRINT CHR$(12)
9030    INPUT "Blood pressures(1) or cardiac
        indices(2)?",Bp
9040    IF Bp=1 THEN
9050        Num_var=9
9060    ELSE
9070        Fst=10
9080        Num_var=13
9090    END IF
9100    IF Pres_in=1 AND Bp=1 THEN
9110        DISP "data in for this xfer; chart displayed"
9120        WAIT 2
9130        Pres_ptr=Pres_ptr-1
9140        IF Heart_in=1 THEN Heart_ptr=Heart_ptr-1
9150        CALL Chart(Chart_num)
9160        IF Heart_in=1 THEN Heart_ptr=Heart_ptr+1
9170        Pres_ptr=Pres_ptr+1
9180        GOTO Keyend
9190    ELSE
9200        IF Heart_in=1 AND Bp=2 THEN
9210            DISP "data in for this xfer; chart
                displayed"
9220            WAIT 2
9230            IF Pres_in=1 THEN Pres_ptr=Pres_ptr-1
9240            Heart_ptr=Heart_ptr-1
9250            CALL Chart(Chart_num)
9260            Heart_ptr=Heart_ptr+1
9270            IF Pres_in=1 THEN Pres_ptr=Pres_ptr-1
9280            GOTO Keyend
9290        ELSE
```

```
9300            INPUT "Input values=1 or display
                chart=2?",Inp
9310            IF Inp=1 THEN
9320                IF Bp=1 AND Pres_ptr>17 THEN
9330                    DISP "Do not enter more Pressure
                        data; disc full"
9340                    WAIT 3
9350                    GOTO Keyend
9360                ELSE
9370                    GOTO I_o
9380                END IF
9390            ELSE
9400                IF Heart_in=1 THEN Heart_ptr=Heart_
                ptr-1
9410                IF Pres_in=1 THEN Pres_ptr=Pres_ptr-1
9420                CALL Chart(Chart_num)
9430                IF Heart_in=1 THEN Heart_ptr=Heart_
                ptr+1
9440                IF Pres_in=1 THEN Pres_ptr=Pres_ptr+1
9450                GOTO Keyend
9460            END IF
9470        END IF
9480    END IF
9490 Data4:!
9500    IF Bp=1 THEN
9510        Pres_time$(Pres_ptr)=Io_msg$(Chart_num,1)
9520        Ao_s(Pres_ptr)=FNLval(Io_msg$(Chart_num,2))
9530        IF Ao_s(Pres_ptr)=9999.999 THEN
9540            Ionum=2
9550            Fix_val=1
9560            GOTO Data_edit
9570        END IF
9580        Ao_d(Pres_ptr)=FNLval(Io_msg$(Chart_num,3))
9590        IF Ao_d(Pres_ptr)=9999.999 THEN
9600            Ionum=3
9610            Fix_val=1
```

```
9620            GOTO Data_edit
9630        END IF
9640        Ao_m(Pres_ptr)=FNLval(Io_msg$(Chart_num,4))
9650        IF Ao_m(Pres_ptr)=9999.999 THEN
9660            Ionum=4
9670            Fix_val=1
9680            GOTO Data_edit
9690        END IF
9700        Pa_s(Pres_ptr)=FNLval(Io_msg$(Chart_num,5))
9710        IF Pa_s(Pres_ptr)=9999.999 THEN
9720            Ionum=5
9730            Fix_val=1
9740            GOTO Data_edit
9750        END IF
9760        Pa_d(Pres_ptr)=FNLval(Io_msg$(Chart_num,6))
9770        IF Pa_d(Pres_ptr)=9999.999 THEN
9780            Ionum=6
9790            Fix_val=1
9800            GOTO Data_edit
9810        END IF
9820        Pa_m(Pres_ptr)=FNLval(Io_msg$(Chart_num,7))
9830        IF Pa_m(Pres_ptr)=9999.999 THEN
9840            Ionum=7
9850            Fix_val=1
9860            GOTO Data_edit
9870        END IF
9880        La_m(Pres_ptr)=FNLval(Io_msg$(Chart_num,8))
9890        IF La_m(Pres_ptr)=9999.999 THEN
9900            Ionum=8
9910            Fix_val=1
9920            GOTO Data_edit
9930        END IF
9940        Ra_m(Pres_ptr)=FNLval(Io_msg$(Chart_num,9))
9950        IF Ra_m(Pres_ptr)=9999.999 THEN
9960            Ionum=9
9970            Fix_val=1
```

```
9980            GOTO Data_edit
9990        END IF
10000       IF Heart_in=1 THEN Heart_ptr=Heart_ptr-1
10010       CALL Chart(Chart_num)
10020       IF Heart_in=1 THEN Heart_ptr=Heart_ptr+1
10030       Pres_ptr=Pres_ptr+1
10040       Pres_in=1
10050       Fix_val=0
10060       GOTO Keyend
10070   ELSE
10080       Heart_time$(Heart_ptr)=Io_msg$(Chart_num,10)
10090       Ci(Heart_ptr)=FNLval(Io_msg$(Chart_num,11))
10100       IF Ci(Heart_ptr)=9999.999 THEN
10110           Ionum=11
10120           Fix_val=1
10130           GOTO Data_edit
10140       END IF
10150       Pvri(Heart_ptr)=FNLval(Io_msg$(Chart_num,12))
10160       IF Pvri(Heart_ptr)=9999.999 THEN
10170           Ionum=12
10180           Fix_val=1
10190           GOTO Data_edit
10200       END IF
10210       Svri(Heart_ptr)=FNLval(Io_msg$(Chart_num,13))
10220       IF Svri(Heart_ptr)=9999.999 THEN
10230           Ionum=13
10240           Fix_val=1
10250           GOTO Data_edit
10260       END IF
10270       IF Pres_in=1 THEN Pres_ptr=Pres_ptr-1
10280       CALL Chart(Chart_num)
10290       IF Pres_in=1 THEN Pres_ptr=Pres_ptr+1
10300       Heart_ptr=Heart_ptr+1
10310       Heart_in=1
10320       Fst=1
10330       Fix_val=0
```

```
10340  END IF
10350  GOTO Keyend
10360  !
10370  !
10380 Key4:Key_id=4
10390  IF Trend_dp=0 THEN
10400      ALLOCATE INTEGER Spectra(7499)
10410      GSTORE Spectra(*)
10420      Trend_dp=2
10430      Top1=200
10440      Top2=2.5
10450      Bot2=-2.5
10460      Top3=10
10470      Top4=10
10480      CALL Trend_graph
10490  ELSE
10500      IF Trend_dp=2 THEN
10510          GRAPHICS ON
10520          GLOAD Spectra(*)
10530          DEALLOCATE Spectra(*)
10540          CALL Offgraph
10550          Trend_dp=0
10560      ELSE
10570          Trend_dp=2
10580          Top1=200
10590          Top2=2.5
10600          Bot2=-2.5
10610          Top3=10
10620          Top4=10
10630          CALL Trend_graph
10640      END IF
10650  END IF
10660  GOTO Keyend
10670  !
10680  !
10690 Key5:Key_id=5
```

```
      !...display message file
10700 IF Msg_dp_request<2 THEN
10710     DISP "messages will be recalled soon"
10720     Msg_dp_request=1
10730     WAIT 1
10740 ELSE
10750     Msg_dp_request=3
10760 END IF
10770 GOTO Keyend
10780 !
10790 !
10800 Key6:Key_id=6                  !..premature program
                                        termination
10810 DISP "To halt program hit KEY 6 again (within 10
          sec)"
10820 ON TIME (TIMEDATE+10) MOD 86400,4 GOTO Keyend
10830 ON KEY 6,3 GOTO Halter
10840 Cancel_wait:GOTO Cancel_wait
10850 Halter:Num_xfer_left=1
10860 Halt_pg=1
10870 GOTO Key_msg
10880 !
10890 !
10900 Key7:Chart_num=3
10910 IF Next_time-TIMEDATE<45 THEN
10920     DISP "not enough time to enter data; wait for
          next xfer"
10930     WAIT 2
10940     GOTO Keyend
10950 END IF
10960 GRAPHICS OFF
10970 PRINT CHR$(12)
10980 Num_var=13
10990 IF Vent_in=1 THEN
11000     DISP "data in for this xfer; chart displayed"
11010     WAIT 2
```

```
11020       Vent_ptr=Vent_ptr-1
11030       CALL Chart(Chart_num)
11040       Vent_ptr=Vent_ptr+1
11050       GOTO Keyend
11060   ELSE
11070       INPUT "Input values=1 or display
chart=2?",Inp
11080       IF Inp=1 THEN
11090           IF Vent_ptr>7 THEN
11100               DISP "Do not enter more Vent data;
                    disc full"
11110               WAIT 3
11120               GOTO Keyend
11130           ELSE
11140               GOTO I_o
11150           END IF
11160       ELSE
11170           CALL Chart(Chart_num)
11180           GOTO Keyend
11190       END IF
11200   END IF
11210 Data3:!
11220   Vent_time$(Vent_ptr)=Io_msg$(Chart_num,1)
11230   Rate(Vent_ptr)=FNLval(Io_msg$(Chart_num,2))
11240   IF Rate(Vent_ptr)=9999.999 THEN
11250       Ionum=2
11260       Fix_val=1
11270       GOTO Data_edit
11280   END IF
11290   Fio2(Vent_ptr)=FNLval(Io_msg$(Chart_num,3))
11300   IF Fio2(Vent_ptr)=9999.999 THEN
11310       Ionum=3
11320       Fix_val=1
11330       GOTO Data_edit
11340   END IF
11350   Pp(Vent_ptr)=FNLval(Io_msg$(Chart_num,4))
```

```
11360 IF Pp(Vent_ptr)=9999.999 THEN
11370     Ionum=4
11380     Fix_val=1
11390     GOTO Data_edit
11400 END IF
11410 Peep(Vent_ptr)=FNLval(Io_msg$(Chart_num,5))
11420 IF Peep(Vent_ptr)=9999.999 THEN
11430     Ionum=5
11440     Fix_val=1
11450     GOTO Data_edit
11460 END IF
11470 Tv(Vent_ptr)=FNLval(Io_msg$(Chart_num,6))
11480 IF Tv(Vent_ptr)=9999.999 THEN
11490     Ionum=6
11500     Fix_val=1
11510     GOTO Data_edit
11520 END IF
11530 Ie_ratio$(Vent_ptr)=Io_msg$(Chart_num,7)
11540 Airp(Vent_ptr)=FNLval(Io_msg$(Chart_num,8))
11550 IF Airp(Vent_ptr)=9999.999 THEN
11560     Ionum=8
11570     Fix_val=1
11580     GOTO Data_edit
11590 END IF
11600 Ph(Vent_ptr)=FNLval(Io_msg$(Chart_num,9))
11610 IF Ph(Vent_ptr)=9999.999 THEN
11620     Ionum=9
11630     Fix_val=1
11640     GOTO Data_edit
11650 END IF
11660 Po2(Vent_ptr)=FNLval(Io_msg$(Chart_num,10))
11670 IF Po2(Vent_ptr)=9999.999 THEN
11680     Ionum=10
11690     Fix_val=1
11700     GOTO Data_edit
11710 END IF
```

```
11720 Pco2(Vent_ptr)=FNLval(Io_msg$(Chart_num,11))
11730 IF Pco2(Vent_ptr)=9999.999 THEN
11740     Ionum=11
11750     Fix_val=1
11760     GOTO Data_edit
11770 END IF
11780 Bgo3(Vent_ptr)=FNLval(Io_msg$(Chart_num,12))
11790 IF Bgo3(Vent_ptr)=9999.999 THEN
11800     Ionum=12
11810     Fix_val=1
11820     GOTO Data_edit
11830 END IF
11840 Be(Vent_ptr)=FNLval(Io_msg$(Chart_num,13))
11850 IF Be(Vent_ptr)=9999.999 THEN
11860     Ionum=13
11870     Fix_val=1
11880     GOTO Data_edit
11890 END IF
11900 CALL Chart(Chart_num)
11910 Vent_ptr=Vent_ptr+1
11920 Vent_in=1
11930 Fix_val=0
11940 GOTO Keyend
11950 !
11960 !
11970 Key8:Chart_num=5
11980 IF Next_time-TIMEDATE<45 THEN
11990     DISP "not enough time to enter data; wait for
          next xfer"
12000     WAIT 2
12010     GOTO Keyend
12020 END IF
12030 GRAPHICS OFF
12040 PRINT CHR$(12)
12050 Num_var=3
12060 IF Drug_in=1 THEN
```

```
12070        DISP "data in for this xfer; chart displayed"
12080        WAIT 2
12090        Drug_ptr=Drug_ptr-1
12100        CALL Chart(Chart_num)
12110        Drug_ptr=Drug_ptr+1
12120        GOTO Keyend
12130    ELSE
12140        INPUT "Input values=1 or display
             chart=2?",Inp
12150        IF Inp=1 THEN
12160            IF Drug_ptr>38 THEN
12170                DISP "Do not enter more Drug data;
                     disc full"
12180                WAIT 3
12190                GOTO Keyend
12200            ELSE
12210                GOTO I_o
12220            END IF
12230        ELSE
12240            CALL Chart(Chart_num)
12250            GOTO Keyend
12260        END IF
12270    END IF
12280 Data5:!
12290    Drug_time$(Drug_ptr)=Io_msg$(Chart_num,3)
12300    Drug_name$(Drug_ptr)=Io_msg$(Chart_num,1)
12310    Drug_dos$(Drug_ptr)=Io_msg$(Chart_num,2)
12320    CALL Chart(Chart_num)
12330    Drug_ptr=Drug_ptr+1
12340    Drug_in=1
12350    GOTO Keyend
12360    !
12370    !
12380 Key9:Key_id=9
12390 Bp_graph: !
12400    IF Next_time-TIMEDATE<12 THEN GOTO Waiter1
```

```
12410  IF Trend_dp=0 THEN
12420      Trend_dp=1
12430      Top1=150
12440      Top2=75
12450      Bot2=0
12460      Top3=50
12470      Top4=50
12480      ALLOCATE INTEGER Spectra(7499)
12490      GSTORE Spectra(*)
12500      CALL Trend_graph
12510  ELSE
12520      IF Trend_dp=1 THEN
12530          GRAPHICS ON
12540          GLOAD Spectra(*)
12550          DEALLOCATE Spectra(*)
12560          CALL Offgraph
12570          Trend_dp=0
12580      ELSE
12590          Trend_dp=1
12600          Top1=150
12610          Top2=75
12620          Bot2=0
12630          Top3=50
12640          Top4=50
12650          CALL Trend_graph
12660      END IF
12670  END IF
12680  GOTO Keyend
12690  !
12700  !
12710 I_o:!
12720  IF TIMEDATE>Next_time-20 THEN
12730      DISP "not enough time to enter data; wait for
           next xfer"
12740      WAIT 2
12750      GOTO Keyend
```

```
12760  END IF
12770  PRINT TABXY(1,1);"enter values"
12780  FOR I=Fst TO Num_var
12790      PRINT TABXY(1,17);"        "
12800      PRINT TABXY(1,17);Io$(Chart_num,I)
12810      Edit_msg$=""
12820      CALL Editor
12830      Io_msg$(Chart_num,I)=Edit_msg$
12840      PRINT TABXY(1,I+2);Io$(Chart_num,I);"=";Io_
           msg$(Chart_num,I)
12850  NEXT I
12860  PRINT TABXY(1,17);"        "
12870  PRINT TABXY(1,18);"        "
12880!
12890!....editting the data
12900!
12910 Io_fix:DISP "Do you want to edit I/O
values?                    (Y/N)"
12920  ENTER 2;Ans$
12930  DISP "                    "
12940  IF Ans$="Y" OR Ans$="y" THEN
12950      IF TIMEDATE>Next_time-15 THEN
12960          DISP "not enough time; data not stored;
               retry next xfer"
12970          GOTO Keyend
12980      END IF
12990      ON Chart_num GOTO Value,Lab,Vent,Pres,Drug
13000 Value:DISP "which value? 1=time, 2=maint. fluid,
              3=other fluids, 4=urine, 5=chest"
13010      ENTER 2;Ionum
13020      IF Ionum<1 OR Ionum>5 THEN GOTO Value
13030      GOTO Data_edit
13040 Lab: DISP "which value?
      1=time,2=Na,3=K,4=Cl,5=HCO3,6=Ca,7=Hct,8=Gluc,9=Di
      g,10=PT,11=PTT,12=Creat,13=Bun"
13050      ENTER 2;Ionum
```

```
13060       IF Ionum<1 OR Ionum>13 THEN GOTO Lab
13070       GOTO Data_edit
13080 Vent:PRINT TABXY(1,17);"which value?
            1=time,2=rate,3=FIO2,4=PP,5=peep,6=TV,
            7=I:E,8=airway"
13090       PRINT TABXY(1,18);
           "9=ph,10=pO2,11=pCO2,12=HCO3,13=Be"
13100       ENTER 2;Ionum
13110       IF Ionum<1 OR Ionum>13 THEN GOTO Vent
13120       GOTO Data_edit
13130 Pres:IF Bp=1 THEN
13140           PRINT TABXY(1,17);"which value? 1=pres
                          time,2=ao/s,3=ao/d,4=ao/m,
                          5=pa/s,6=pa/d,7=pa/m,8=la,9=ra"
13150       ELSE
13160           PRINT TABXY(1,18);"which value? 10=heart
                time,11=c.i.,12=pvri,13=svri"
13170       END IF
13180       ENTER 2;Ionum
13190       IF Ionum<1 OR Ionum>13 THEN GOTO Pres
13200       GOTO Data_edit
13210 Drug:DISP "which value? 1=name,2=dosage,3=time"
13220       ENTER 2;Ionum
13230       IF Ionum<1 OR Ionum>10 THEN GOTO Drug
13240       GOTO Data_edit
13250 Data_edit:!
13260       IF TIMEDATE>Next_time-15 THEN
13270           DISP "not enough time; data not stored;
                retry next xfer"
13280           WAIT 2
13290           GOTO Keyend
13300       END IF
13310       C_num=Chart_num
13320       R_num=2
13330       IF Fix_val=1 THEN
13340           PRINT TABXY(1,17);"Error on input; enter
```

```
                 value again"
13350            PRINT TABXY(1,18);Io$(C_num,Ionum)
13360        END IF
13370        PRINT TABXY(1,18);Io_msg$(C_num,Ionum)
13380        Edit_msg$=Io_msg$(C_num,Ionum)
13390        CALL Editor
13400        Io_msg$(C_num,Ionum)=Edit_msg$
13410        PRINT TABXY(1,Ionum+R_num);"      "
13420        PRINT TABXY(1,Ionum+R_num);Io$(C_
             num,Ionum);"=";Edit_msg$
13430        PRINT TABXY(1,17);"               "
13440        PRINT TABXY(1,18);"               "
13460        GOTO Io_fix
13470    ELSE
13480        ON Chart_num GOTO
               Data1,Data2,Data3,Data4,Data5
13490    END IF
13500 Keyend:OFF TIME
13510    OFF KBD
13520    RETURN
13530    END
13540    !
13550    !
13560    !
13570    !
13580    !
13590    SUB Pauser
13600        DISP "press CONTINUE to continue"
13610        PAUSE
13620        DISP
13630    SUBEND
13640    !
13650    !
13660    !
13670    !
13680    !
```

```
13690  SUB Get_param
13700      COM /Multi_param/ Start_chan,Stop_chan,Pacing_
           bits,Pacing_rate,Num_pt
           s,Num_xfer,Num_xfer_left,Name_len,Scr_
             file$[28],Scr_
        file2$[28]
13710      COM /Messagecom/ Message$(10)[80],@Messages
13720      COM /Trends/ Mean_hr_t(*),Lfa_t(*),Rfa_
           t(*),Ratio_t(*),T_ptr,Time_now
           l,Meas_resp_t(*),Trend_dp
13730      COM /Vitaldata/ Rfa,Lfa,Peakratio,Meas_
           resp,Next_time
13740      COM /Pressure/
           Top1,Top2,Top3,Top4,Bot1,Bot2,Bot3,Bot4
13750      COM /Pres_chart/ Pres_time$(*),Ao_s(*),Ao_
           d(*),Ao_m(*),Pa_s(*),Pa_d(*
           ),Pa_m(*),La_m(*),Ra_m(*),Pres_ptr,Pres_in
13760      COM /Subject/ Sub_name$[25],Hos_num$[15],Id_
           age$[10],Id_wt$[10],Id_ht
           $[10],Diag$[30],Opera$[45],Halt_pg
13770      COM /Io_chart/ Io_time$(*),Iv_intake(*),Fluid_
           in(*),In_tot(*),Urine(*
           ),Chest(*),Out_tot(*),Net(*),Io_ptr
13780      COM /Lab_chart/ Lab_
           time$(*),Na(*),Kl(*),Cl(*),Hco3(*),
              Ca(*),Hct(*),Gluc(*),Dig(*),Pt(*),
              Ptt(*),Creat(*),Bun(*),Lab_ptr
13790      COM /Vent_chart/ Vent_
         time$(*),Rate(*),Fio2(*),Pp(*),Peep(*),Tv(*),Ie
           _ratio$(*),Airp(*),Ph(*),Po2(*),Pco2(*),
           Bgo3(*),Be(*),Vent_ptr
13800      COM /Heart_index/ Heart_
           time$(*),Ci(*),Pvri(*),Svri(*),Heart_ptr
13810      COM /Drugs/ Drug_time$(*),Drug_name$(*),Drug_
           dos$(*),Drug_ptr
13820      DIM Mo$[24]
```

```
13830       Mo$="JAFBMRAPMYJNJLAUSPOCNODC"
13840   !   INTEGER Id_buffer(255) BUFFER
13850       Disk_name$=":HP8290X,700,1"
13860       IF Halt_pg=1 THEN GOTO Purger_get!.....quit
            program
13870 !
13880 ! change soft key messages
13890 !
13900 Oldmsg:PRINT CHR$(12)
13910       PRINT "These are the current soft key
            messages:"
13920       FOR I=0 TO 9
13930           PRINT "KEY";I;":";Message$(I)
13940       NEXT I
14100       DISP "Press cont when ready to continue"
14110       PAUSE
14120!
14130       INPUT "Enter subject name, 10 chars (Doe if
            unknown)",Sub_name$
14140       Sub_name$=Sub_name$[1,10]
14150       INPUT "Enter hospital number, 8 chars (00 if
            unknown):",Hos_num$
14160       Hos_num$=Hos_num$[1,8]
14170       INPUT "Enter subject age(00 if unknown):",Id_
            age$
14180       INPUT "Enter subject weight,kg (00 if
            unknown):",Id_wt$
14190       INPUT "Enter subject height,cm (00 if
            unknown):",Id_ht$
14200       INPUT "Enter diagnosis, 10 chars (Unk if
            unknown):",Diag$
14210       Diag$=Diag$[1,10]
14220       INPUT "Enter operation, 15 chars (Unk if
            unknown):",Opera$
14230       Opera$=Opera$[1,15]
14240!
```

```
14250 Ch_sel:!
14260      Start_chan=0
14270      Stop_chan=0
14280 !
14290      Pacing_bits=0
14300 Pacing_sel:!
14310      Base$="M"
14320      Pacing_bits=261
14330 !
14340      Base$=Base$&"SEC"
14350 !
14360 !
14370 ! FINDOUT BLOCKSIZE FOR DATA TRANSFER
14380 !
14390      Num_xfer=55
14400!
14410! since new data is to be taken, zero the trend
       graphs (120 pts=8hrs)
14420!
14430      MAT Mean_hr_t= (0)
14440      MAT Rfa_t= (0)
14450      MAT Lfa_t= (0)
14460      MAT Ratio_t= (0)
14470      MAT Meas_resp_t= (0)
14471      MAT Trans_time= (0)
14480      T_ptr=0
14490      MAT Pres_time$= ("")
14500      MAT Ao_s= (0)
14510      MAT Ao_d= (0)
14520      MAT Ao_m= (0)
14530      MAT Pa_s= (0)
14540      MAT Pa_d= (0)
14550      MAT Pa_m= (0)
14560      MAT La_m= (0)
14570      MAT Ra_m= (0)
14580      MAT Io_time$= ("")
```

```
14590     MAT Iv_intake= (0)
14600     MAT Fluid_in= (0)
14610     MAT In_tot= (0)
14620     MAT Urine= (0)
14630     MAT Chest= (0)
14640     MAT Out_tot= (0)
14650     MAT Net= (0)
14660     MAT Lab_time$= ("")
14670     MAT Na= (0)
14680     MAT Kl= (0)
14690     MAT Cl= (0)
14700     MAT Hco3= (0)
14710     MAT Ca= (0)
14720     MAT Hct= (0)
14730     MAT Gluc= (0)
14740     MAT Dig= (0)
14750     MAT Pt= (0)
14760     MAT Ptt= (0)
14770     MAT Creat= (0)
14780     MAT Bun= (0)
14790     MAT Vent_time$= ("")
14800     MAT Rate= (0)
14810     MAT Fio2= (0)
14820     MAT Pp= (0)
14830     MAT Peep= (0)
14840     MAT Tv= (0)
14850     MAT Ie_ratio$= ("")
14860     MAT Airp= (0)
14870     MAT Ph= (0)
14880     MAT Po2= (0)
14890     MAT Pco2= (0)
14900     MAT Bgo3= (0)
14910     MAT Be= (0)
14920     MAT Heart_time$= ("")
14930     MAT Ci= (0)
14940     MAT Pvri= (0)
```

```
14950      MAT Svri= (0)
14960      MAT Drug_time$= ("")
14970      MAT Drug_name$= ("")
14980      MAT Drug_dos$= ("")
14990      Pres_ptr=0
15000      Trend_ptr=0


15010      Ratio_t(0)=1 !..prevent trend graph errors on
           startup
15020      Rfa=0
15030      Lfa=0
15040      Meas_resp=0
15050      Peakratio=1
15060  !
15070  !
15080      Pacing_rate=250
15090      Num_pts=1024*Num_xfer
15100      Num_header=256+8*Num_xfer
15110      IF Scr_file$="?" THEN GOTO Skip1
15120 Purger_get:DISP "PURGE FILE?"
15130      ENTER 2;Resp$
15140      IF Resp$="Y" OR Resp$="YES" THEN
15150          PURGE Scr_file$
15160          PURGE Scr_file2$
15170          PURGE "messglog:HP8290X,700,1"
15180          PURGE "temp_trend:HP8290X,700,1"
15190          PURGE "hemo_data:HP8290X,700,1"
15200          PURGE "io_data:HP8290X,700,1"
15210          PURGE "drug_data:HP8290X,700,1"
15220          PURGE "lab_data:HP8290X,700,1"
15230          PURGE "co_data:HP8290X,700,1"
15231          PURGE "sub_data:HP8290X,700,1"
15240      ELSE
15250!
15260! the data files are named according to the date
```

```
15270! in the following format:
15280!     xxxxmmddyy
15290! where
15300!     xxxx - resp,hr__,msgs,errs,trnd
15310!     dd   - day
15320!     mm   - month
                (JA,FB,MR,AP,MY,JN,JL,AU,SP,OC,NO,DC)
15330!     yy   - year
15340          Date_now$=DATE$(TIMEDATE)
15350          Month_now=FNMonth(Date_now$)*2-1
15360          Mm$=Mo$[Month_now;2]
15370          Id_field$=Date_now$[1;2]&Mm$&Date_
               now$[10;2]
15380! new name for respiratory file: respddmmyy
15390          RENAME Scr_file$ TO "resp"&Id_field$&Disk_
               name$
15400! new name for heart rate file: hr__ddmmyy
15410          RENAME Scr_file2$ TO "hr__"&Id_
               field$&Disk_name$
15420! new name for message log: msgsddmmyy
15430          RENAME "messglog:HP8290X,700,1" TO
               "msgs"&Id_field$&Disk_name$
15440! new name for hemo data: dataddmmyy
15450          RENAME "hemo_data:HP8290X,700,1" TO
               "hemo"&Id_field$&Disk_name$
15460! new name for io data
15470          RENAME "io_data:HP8290X,700,1" TO "io__
               "&Id_field$&Disk_name$
15480! new name for lab data
15490          RENAME "lab_data:HP8290X,700,1" TO "lab_
               "&Id_field$&Disk_name$
15500! new name for vent data
15510          RENAME "vent_data:HP8290X,700,1" TO
               "vent"&Id_field$&Disk_name$
15520! new name for co data
15530          RENAME "co_data:HP8290X,700,1" TO "co__
```

```
                "&Id_field$&Disk_name$
15540! new name for drug data
15550           RENAME "drug_data:HP8290X,700,1" TO
                "drug"&Id_field$&Disk_name$
15551! new name for subject data
15552           RENAME "sub_data:HP8290X,700,1" TO "sub_
                "&Id_field$&Disk_name$
15560! name for trend summary file: trndddmmyy
15570           PURGE "temp_trend:HP8290X,700,1"
15580           CREATE BDAT "trnd"&Id_field$&Disk_
                name$,19,256
15590           ASSIGN @Trend_file TO "trnd"&Id_
                field$&Disk_name$;FORMAT OFF
15600           OUTPUT @Trend_file;Mean_hr_t(*),Lfa_
                t(*),Rfa_t(*),Ratio_t(*),Meas
                  _resp_t(*),Trans_time(*),T_ptr
15610           ASSIGN @Trend_file TO *
15620       END IF
15630       IF Halt_pg=1 THEN     !..terminate program
15640           DISP "PROGRAM COMPLETED"
15650           STOP
15660       END IF
15670 Skipl:DISP
15680       Scr_file$="AOK"&Disk_name$
15690       Num_rec=-INT(-(Num_pts+Num_header)/128.)
15700       Scr_file2$="hr"&Scr_file$
15710       CREATE BDAT Scr_file$,Num_rec,256
15720       CREATE BDAT Scr_file2$,Num_rec,256
15730       CREATE BDAT "messglog:HP8290X,700,1",20,640
15740       CREATE BDAT "temp_trend"&Disk_name$,19,256
15750       CREATE BDAT "hemo_data"&Disk_name$,10,256
15760       CREATE BDAT "io_data"&Disk_name$,10,256
15770       CREATE BDAT "lab_data"&Disk_name$,10,256
15780       CREATE BDAT "vent_data"&Disk_name$,10,256
15790       CREATE BDAT "co_data"&Disk_name$,10,256
15800       CREATE BDAT "drug_data"&Disk_name$,10,256
```

```
15801       CREATE BDAT "sub_data"&Disk_name$,1,256
15802       ASSIGN @Sub_data TO "sub_data"&Disk_
            name$;FORMAT OFF
15803       OUTPUT @Sub_data;Sub_name$,Hos_num$,Id_
            age$,Id_wt$,Id_ht$,Diag$,Opera$
15804       ASSIGN @Sub_data TO *
15810       Halt_pg=0
15820       Num_pts=1024
15830       PRINT Num_pts*Num_xfer;"points will be
            transferred in";Num_xfer;"bloc
            ks of";Num_pts;"points"
15840   !
15850       Num_xfer_left=Num_xfer
15860   SUBEND
15870   !
15880   !
15890   !
15900   !
15910   DEF FNMonth(Date_now$)
15920       Month$=Date_now$[4;3]
15930       Month=0
15940       IF Month$="Jan" THEN Month=1
15950       IF Month$="Feb" THEN Month=2
15960       IF Month$="Mar" THEN Month=3
15970       IF Month$="Apr" THEN Month=4
15980       IF Month$="May" THEN Month=5
15990       IF Month$="Jun" THEN Month=6
16000       IF Month$="Jul" THEN Month=7
16010       IF Month$="Aug" THEN Month=8
16020       IF Month$="Sep" THEN Month=9
16030       IF Month$="Oct" THEN Month=10
16040       IF Month$="Nov" THEN Month=11
16050       IF Month$="Dec" THEN Month=12
16060       RETURN Month
16070   FNEND
16080!
```

```
16090!
16100!
16110!
16120!
16130  SUB Xfheader(@Disk,Num_bytes,File_id$)
16140      INTEGER Xheader(7) BUFFER
16150      Xheader(0)=(TIMEDATE MOD 86400)/60
16160      Xheader(1)=Num_bytes
16170      Xheader(2)=NUM(File_id$[1;1])
16180      Xheader(3)=0
16190      Xheader(4)=0
16200      Xheader(5)=0
16210      Xheader(6)=0
16220      Xheader(7)=0
16230      ASSIGN @Xheader TO BUFFER Xheader(*)
16240      CONTROL @Xheader,5;1   ! Reset empty pointer
           for buffer
16250      CONTROL @Xheader,4;16  ! Reset current number
           of bytes in buffer
16260      TRANSFER @Xheader TO @Disk;COUNT 16,WAIT
16270      ASSIGN @Xheader TO *
16280  SUBEND
16290!
16300!
16310!
16320!
16330!
16340!
16350  SUB Trend_graph
16360!
16370      COM /Trends/ Mean_hr_t(*),Lfa_t(*),Rfa_
           t(*),Ratio_t(*),T_ptr,Time_now
           1,Meas_resp_t(*),Trend_dp,Trans_time(*),Lfa_
             top,Rfa_top
16380      COM /Multi_param/ Start_chan,Stop_chan,Pacing_
           bits,Pacing_rate,Num_pt
```

```
              s,Num_xfer,Num_xfer_left,Name_len,Scr_
                file$[28],Scr_
              file2$[28]
     16390    COM /Pressure/
              Top1,Top2,Top3,Top4,Bot1,Bot2,Bot3,Bot4
     16400    COM /Pres_chart/ Pres_time$(*),Ao_s(*),Ao_
              d(*),Ao_m(*),Pa_s(*),Pa_d(*
                ),Pa_m(*),La_m(*),Ra_m(*),Pres_ptr,Pres_in
     16410    DIM First_line(60),Sec_line(60),Third_
              line(60),Fourth_line(60)
     16420    IF Trend_dp=1 THEN
     16430        MAT First_line= Ao_m
     16440        MAT Sec_line= Pa_m
     16450        MAT Third_line= La_m
     16460        MAT Fourth_line= Ra_m
     16470        G_right=INT((Num_xfer*256/60)/15)
     16480    !   IF Pres_in=0 THEN !   Trend_ptr=Pres_
              ptr+1
     16490    !       Trend_ptr=Pres_ptr+1
     16500    !   ELSE
     16510        Trend_ptr=Pres_ptr
     16520    !   END IF
     16530    ELSE
     16540        MAT First_line= Mean_hr_t
     16550        MAT Sec_line= Ratio_t
     16560        MAT Third_line= Lfa_t
     16570        MAT Fourth_line= Rfa_t
     16580        G_right=Num_xfer
     16590        Trend_ptr=T_ptr
     16600    END IF
     16610    Block_time=Pacing_rate*1.024/3600.
     16620    GINIT
     16630    GCLEAR
     16640    PRINT CHR$(12)
     16650    GRAPHICS ON
     16660    Beg_time=Time_now1/3600-Block_time
```

```
16670        End_time=Beg_time+Num_xfer*Block_time
16680        Ibeg_time=INT(Beg_time)
16690        IF Ibeg_time<Beg_time THEN Ibeg_time=Ibeg_
             time+1
16700!
16710! label the time axes
16720!
16730        VIEWPORT 0,128,45,50
16740        WINDOW Beg_time,End_time,0,1
16750        IF INT(End_time)>Beg_time THEN
16760            LDIR 0
16770            FOR T_label=Ibeg_time TO INT(End_time)
16780                MOVE T_label,.5
16790                LORG 5
16800                CSIZE 4
16810                LABEL T_label
16820            NEXT T_label
16830        END IF
16840        VIEWPORT 0,128,40,45
16850        WINDOW 0,1,0,1
16860        MOVE .5,0
16870        LORG 4
16880        LABEL "Time (24 hr)"
16890!
16900! draw the axes
16910!
16920        VIEWPORT 0,128,50,100
16930        WINDOW Beg_time,End_time,0,1
16940        AXES 1/15.,.1,Beg_time,0
16950        WINDOW 1,0,1,0
16960        AXES 0,.25,0,0
16970!
16980! mean heart rate trends
16990!
17000        WINDOW -1,G_right,Botl,Topl
17010        MOVE 0,First_line(0)
```

```
17020      FOR I=0 TO Trend_ptr-1
17030          DRAW I,First_line(I)
17040      NEXT I
17050!
17060! ratio trends (with a line at ratio=2)
17070!
17080      WINDOW -1,G_right,Bot2,Top2
17090      LINE TYPE 8,5
17100      IF Trend_dp=2 THEN
17110          MOVE 0,LGT(Sec_line(0))
17120      ELSE
17130          MOVE 0,Sec_line(0)
17140      END IF
17150      FOR I=0 TO Trend_ptr-1
17160          IF Trend_dp=2 THEN
17170              DRAW I,LGT(Sec_line(I))
17180          ELSE
17190              DRAW I,Sec_line(I)
17200          END IF
17210      NEXT I
17220      IF Trend_dp=2 THEN
17230          LINE TYPE 3,5!..sparsely dotted line at
               ratio=2
17240          MOVE 0,LGT(2.)
17250          DRAW Trend_ptr-1,LGT(2.)
17260      END IF
17270!
17280! lfa trends
17290!
17300      WINDOW -1,G_right,Bot3,Top3
17310      LINE TYPE 4,5
17320      MOVE 0,Third_line(0)
17330      FOR I=0 TO Trend_ptr-1
17340          DRAW I,Third_line(I)
17350      NEXT I
17360!
```

```
17370! rfa trends
17380!
17390       WINDOW -1,G_right,Bot4,Top4
17400       LINE TYPE 5,5
17410       MOVE 0,Fourth_line(0)
17420       FOR I=0 TO Trend_ptr-1
17430           DRAW I,Fourth_line(I)
17440       NEXT I
17450!
17460! draw a key for line types
17470!
17480       VIEWPORT 64,128,0,50
17490       WINDOW 0,1,0,13
17500       IF Trend_dp=2 THEN
17510           PRINT TABXY(1,17);"trend graph"
17520           PRINT TABXY(55,15);"mean hr(0-200)"
17530           PRINT TABXY(55,16);"ratio(.01-100)"
17540           PRINT TABXY(55,17);"lfa    (0-10)"
17550           PRINT TABXY(55,18);"rfa    (0-10)"
17560       ELSE
17570           PRINT TABXY(1,17);"mean pressure graphs"
17580           PRINT TABXY(50,15);"ao pressure(0-150)"
17590           PRINT TABXY(50,16);"pa pressure(0-75)"
17600           PRINT TABXY(50,17);"la pressure(0-50)"
17610           PRINT TABXY(50,18);"ra pressure(0-50)"
17620       END IF
17630       LINE TYPE 1,5
17640       MOVE .8,11
17650       DRAW 1.,11
17660       LINE TYPE 8,5
17670       MOVE .8,10
17680       DRAW 1.,10
17690       LINE TYPE 4,5
17700       MOVE .8,9
17710       DRAW 1.,9
17720       LINE TYPE 5,5
```

```
17730       MOVE .8,8
17740       DRAW 1.,8
17750   SUBEND
17760!
17770!
17780!
17790!
17800!
17810   SUB Msg_dump(Message_chart$(*),Message_line,Flg)
17820       COM /Messagecom/ Message$(10)[80],@Messages
17830       DIM Msg_buffer$[1280] BUFFER
17840       IF Flg>=2 THEN GOTO Chart_filled
17850       ASSIGN @Msg_buffer TO BUFFER Msg_
            buffer$;FORMAT OFF
17860       STATUS @Messages,3;Num_rec
17870       STATUS @Messages,4;Rec_len
17880       STATUS @Messages,5;Cur_rec
17890       STATUS @Messages,6;Cur_byte
17900       IF Cur_rec<=1 AND Cur_byte<=1 THEN !.. no
            messages yet
17910           Flg=0
17920           DISP "no messages yet"
17930           WAIT 2
17940           SUBEXIT
17950       END IF
17960       Flg=2
17970       CONTROL @Messages,5;1
17980       CONTROL @Messages,6;1
17990       FOR Rec=1 TO Cur_rec-1
18000 Read_msg:TRANSFER @Messages TO @Msg_buffer;COUNT
                Rec_len,WAIT
18010           Message_chart$(Rec-1)=Msg_buffer$[1;Rec_
                len]
18020           CONTROL @Msg_buffer,4;0
18030           CONTROL @Msg_buffer,5;1
18040       NEXT Rec
```

```
18050       IF Cur_byte>1 THEN
18060         TRANSFER @Messages TO @Msg_buffer;COUNT
              Cur_byte-1,WAIT
18070         Message_chart$(Cur_rec-1)=Msg_
              buffer$[1;Cur_byte-1]
18080       END IF
18090       ASSIGN @Msg_buffer TO *
18100 Reset_msg_file:!
18110       CONTROL @Messages,5;Cur_rec
18120       CONTROL @Messages,6;Cur_byte
18130 Chart_filled:!
18140       STATUS @Messages,5;Cur_rec
18150       STATUS @Messages,6;Cur_byte
18160       Flg=2
18170       Cur_msg_ptr=0
18180       Chart_line=1
18190       Msg_buffer$=Message_chart$(0)
18200       Last_msg=Message_line+17
18210       Clear$=CHR$(255)&CHR$(75)
18220       OUTPUT 2;Clear$
18230       GRAPHICS OFF
18240 Next_msg:!
18250       Beg_msg=POS(Msg_buffer$[4],"Time")+3
18260       IF Beg_msg=3 THEN GOTO Next_chart_line
18270       Cur_msg_ptr=Cur_msg_ptr+1
18280       IF Cur_msg_ptr>Message_line THEN
18290         Tab_line=Cur_msg_ptr-Message_line
18300         PRINT TABXY(1,Tab_line);"        "
18310         PRINT TABXY(1,Tab_line);Msg_buffer$[1,Beg_
                msg-1]
18320       END IF
18330       Msg_buffer$=Msg_buffer$[Beg_msg]
18340       IF Cur_msg_ptr=Last_msg THEN Subend_msg
18350       GOTO Next_msg
18360 Next_chart_line:IF Chart_line<Cur_rec THEN
18370         Msg_buffer$=Msg_buffer$&Message_
```

```
                    chart$(Chart_line)
18380           Chart_line=Chart_line+1
18390           GOTO Next_msg
18400       END IF
18410 Stopper:PRINT Msg_buffer$
18420 Subend_msg:PRINT
18430  SUBEND
18440 !
18450 !
18460 !
18470 !
18480 !
18490  SUB Disp_ctrls
18500      DISP "f̂ - freq range adjust (1 or 2 Hz)"
18510      WAIT 2
18520      DISP "ĥ - help: display these controls"
18530      WAIT 2
18540      DISP "p̂ - peak threshold adjust (+20%)"
18550      WAIT 2
18560      DISP "r̂ - resp time series display"
18570      WAIT 2
18580      DISP "ŝ - search for resp peak (+.1 Hz)"
18590      WAIT 2
18600  SUBEND
18610 !
18620 !
18630 !
18640  SUB Offgraph
18650      COM /Vitaldata/ Rfa,Lfa,Peakratio,Meas_
             resp,Next_time
18660      PRINT CHR$(12)
18670      PRINT TABXY(1,14);"RR=";PROUND(Meas_resp,-
             2);"Hz"
18680      PRINT TABXY(1,15);"lfa=";Lfa
18690      PRINT TABXY(1,16);"rfa=";Rfa
18700      PRINT TABXY(1,17);"ratio=";Peakratio
```

```
18710       PRINT TABXY(1,18);"next transfer:
            ";TIME$(Next_time)
18720  SUBEND
18730       !
18740       !
18750       ! This subroutine edits the data
18760       !
18770       !
18780  SUB Editor
18790       COM /Editor/ Edit_msg$[80]
18800       COM /Vitaldata/ Rfa,Lfa,Peakratio,Meas_
            resp,Next_time
18810 Key_in:!
18820       PRINT TABXY(1,18);"                "
18830       PRINT TABXY(1,18);Edit_msg$
18840       IF TIMEDATE>Next_time-15 THEN GOTO Keyend
18850       ON TIME (TIMEDATE+10) MOD 86400,3 GOTO Keyend
18860       DISP "type message"
18870       GRAPHICS OFF
18880       ON KBD,2 GOTO Next_char
18890 Key_wait:GOTO Key_wait
18900 Next_char:Key$=KBD$
18910       ON TIME (TIMEDATE+10) MOD 86400,3 GOTO Keyend
18920       IF NUM(Key$)=255 THEN
18930           IF NUM(Key$[2])=69 THEN GOTO End_key
18940           IF NUM(Key$[2])=66 THEN !..backspacing
18950               New_msg_len=LEN(Edit_msg$)-1
18960               IF New_msg_len<=0 THEN New_msg_len=0
18970               Edit_msg$=Edit_msg$[1;New_msg_len]
18980           END IF
18990           IF NUM(Key$[2])=35 THEN !..clear line
19000               Edit_msg$=""
19010           END IF
19020       ELSE
19030           IF LEN(Edit_msg$)<66 THEN !..can add
          ! characters
```

```
19040              Edit_msg$=Edit_msg$&Key$
19050          ELSE
19060              BEEP
19070          END IF
19080      END IF
19090      PRINT TABXY(1,18);"                  "
19100      PRINT TABXY(1,18);Edit_msg$
19110      GOTO Key_wait
19120 Keyend: !
19130 End_key:OFF KBD
19140      OFF TIME
19150  SUBEND
19160 !
19170 !
19180 !
19190  SUB Chart(Chart_num)
19200      COM /Subject/ Sub_name$,Hos_num$,Id_age$,Id_
           wt$,Id_ht$,Diag$,Opera$,Halt_pg
19210      COM /Io_chart/ Io_time$(*),Iv_intake(*),Fluid_
           in(*),In_tot(*),Urine(*),Chest(*),Out_
              tot(*),Net(*),Io_ptr
19220      COM /Lab_chart/ Lab_
      time$(*),Na(*),Kl(*),Cl(*),Hco3(*),Ca(*),Hct(*),G
        luc(*),Dig(*),Pt(*),Ptt(*),Creat(*),Bun(*),Lab_
          ptr
19230      COM /Vent_chart/ Vent_
         time$(*),Rate(*),Fio2(*),Pp(*),Peep(*),Tv(*),
          Ie_ratio$(*),Airp(*),Ph(*),Po2(*),Pco2(*),
           Bgo3(*),Be(*),Vent_ptr
19240      COM /Pres_chart/ Pres_time$(*),Ao_s(*),Ao_
           d(*),Ao_m(*),Pa_s(*),Pa_d(*
             ),Pa_m(*),La_m(*),Ra_m(*),Pres_ptr,Pres_in
19250      COM /Pressure/
           Top1,Top2,Top3,Top4,Bot1,Bot2,Bot3,Bot4
19260      COM /Heart_index/ Heart_
           time$(*),Ci(*),Pvri(*),Svri(*),Heart_ptr
```

```
19270      COM /Drugs/ Drug_time$(*),Drug_name$(*),Drug_
           dos$(*),Drug_ptr
19280      Pres_stl=0
19290      Lab_stl=0
19300      Io_stl=0
19310      Vent_stl=0
19320      Drug_stl=0
19330      !
19340      ! set up identifying subject info
19350      !
19360      PRINT CHR$(12)
19370      PRINT TABXY(1,1);
19380      PRINT USING Image_wtl;Sub_name$,Hos_
           num$,TIME$(TIMEDATE),DATE$(TIMEDATE)
19390 Image_wtl:IMAGE   "Name: ",K,XXXX,"Hosp num:
           ",K,XXXXX,K,XXXXX,K
19400      PRINT TABXY(1,2);
19410      PRINT USING Image_wt2;Id_age$,Id_wt$,Id_
           ht$,Diag$,Opera$
19420 Image_wt2:IMAGE   "Age: ",K,XXXX,"Wt(kg):
           ",K,XXXX,"Ht(cm): ",K,XXXX,"Diag
              : ",K,XXXX,"Op: ",K
19430      !
19440      ! go to appropriate chart
19450      !
19460      ON Chart_num GOTO In_out,Lab_val,Vent_
           val,Pres_val,Drug
19470 In_out:!                          ....intake/output
19480      IF Io_ptr>3 THEN Io_stl=2
19490      IF Io_ptr>5 THEN
19500          DISP "do not input more Intake/Output
               data; disc full"
19510          WAIT 3
19520          SUBEXIT
19530      END IF
19540      PRINT TABXY(30,3);"INTAKE/OUTPUT CHART"
```

```
19550       PRINT TABXY(1,4);"Intake (cc/hr) "
19560       PRINT TABXY(1,5);"Time"
19570       PRINT TABXY(4,6);"Maint. Fluid"
19580       PRINT TABXY(4,7);"Other Fluids"
19590       PRINT TABXY(1,9);"Total "
19600       PRINT TABXY(1,11);"Output (cc/hr)"
19610       PRINT TABXY(4,12);"Urine"
19620       PRINT TABXY(4,13);"Chest"
19630       PRINT TABXY(1,15);"Total"
19640       PRINT TABXY(1,17);"Net I/O"
19650       Start=25
19660       FOR I=Io_stl TO Io_ptr
19670           PRINT TABXY(Start,5);Io_time$(I)
19680           PRINT TABXY(Start,6);Iv_intake(I)
19690           PRINT TABXY(Start,7);Fluid_in(I)
19700           PRINT TABXY(Start,9);In_tot(I)
19710           PRINT TABXY(Start,12);Urine(I)
19720           PRINT TABXY(Start,13);Chest(I)
19730           PRINT TABXY(Start,15);Out_tot(I)
19740           PRINT TABXY(Start,17);Net(I)
19750           Start=Start+10
19760       NEXT I
19770       GOTO Finish
19780!
19790!
19800 Lab_val:!         ...lab values
19810       IF Lab_ptr>3 THEN Lab_stl=2
19820       IF Lab_ptr>7 THEN
19830           DISP "do not input any more lab values;
                  disc full"
19840           WAIT 3
19850           SUBEXIT
19860       END IF
19870       PRINT TABXY(30,3);"Lab Values"
19880       PRINT TABXY(10,4);"Time"
19890       PRINT TABXY(1,6);"Na"
```

```
19900       PRINT TABXY(1,7);"K"
19910       PRINT TABXY(1,8);"Cl"
19920       PRINT TABXY(1,9);"HCO3"
19930       PRINT TABXY(1,10);"Ca"
19940       PRINT TABXY(1,11);"Hct"
19950       PRINT TABXY(1,12);"Glucose"
19960       PRINT TABXY(1,13);"Dig level"
19970       PRINT TABXY(1,14);"PT"
19980       PRINT TABXY(1,15);"PTT"
19990       PRINT TABXY(1,16);"Creat"
20000       PRINT TABXY(1,17);"Bun"


20010       Start=15
20020       FOR I=Lab_stl TO Lab_ptr
20030           PRINT TABXY(Start+10,4);Lab_time$(I)
20040           PRINT TABXY(Start+10,6);Na(I)
20050           PRINT TABXY(Start+10,7);Kl(I)
20060           PRINT TABXY(Start+10,8);Cl(I)
20070           PRINT TABXY(Start+10,9);Hco3(I)
20080           PRINT TABXY(Start+10,10);Ca(I)
20090           PRINT TABXY(Start+10,11);Hct(I)
20100           PRINT TABXY(Start+10,12);Gluc(I)
20110           PRINT TABXY(Start+10,13);Dig(I)
20120           PRINT TABXY(Start+10,14);Pt(I)
20130           PRINT TABXY(Start+10,15);Ptt(I)
20140           PRINT TABXY(Start+10,16);Creat(I)
20150           PRINT TABXY(Start+10,17);Bun(I)
20160           Start=Start+10
20170       NEXT I
20180       GOTO Finish
20190!
20200!
20210 Vent_val:!                       ....ventilation values
20220       IF Vent_ptr>3 THEN Vent_stl=2
20230       IF Vent_ptr>5 THEN Vent_stl=4
```

```
20240    IF Vent_ptr>7 THEN
20250        DISP "do not input any more Vent values;
             disc full"
20260        WAIT 3
20270        SUBEXIT
20280    END IF
20290    PRINT TABXY(30,3);"VENTILATION"
20300    PRINT TABXY(1,4);"Settings          Hour:"
20310    PRINT TABXY(4,5);"Rate"
20320    PRINT TABXY(4,6);"FIO2"
20330    PRINT TABXY(4,7);"Peak Pres"
20340    PRINT TABXY(4,8);"Peep"
20350    PRINT TABXY(4,9);"TV"
20360    PRINT TABXY(4,10);"I:E ratio"
20370    PRINT TABXY(4,11);"Mean air"
20380    PRINT TABXY(1,12);"Blood Gases"
20390    PRINT TABXY(4,13);"ph"
20400    PRINT TABXY(4,14);"pO2"
20410    PRINT TABXY(4,15);"pCO2"
20420    PRINT TABXY(4,16);"HCO3"
20430    PRINT TABXY(4,17);"BE"
20440    Start=15
20450    FOR I=Vent_stl TO Vent_ptr
20460        PRINT TABXY(Start+10,4);Vent_time$(I)
20470        PRINT TABXY(Start+10,5);Rate(I)
20480        PRINT TABXY(Start+10,6);Fio2(I)
20490        PRINT TABXY(Start+10,7);Pp(I)
20500        PRINT TABXY(Start+10,8);Peep(I)
20510        PRINT TABXY(Start+10,9);Tv(I)
20520        PRINT TABXY(Start+10,10);Ie_ratio$(I)
20530        PRINT TABXY(Start+10,11);Airp(I)
20540        PRINT TABXY(Start+10,13);Ph(I)
20550        PRINT TABXY(Start+10,14);Po2(I)
20560        PRINT TABXY(Start+10,15);Pco2(I)
20570        PRINT TABXY(Start+10,16);Bgo3(I)
20580        PRINT TABXY(Start+10,17);Be(I)
```

```
20590          Start=Start+10
20600      NEXT I
20610      GOTO Finish
20620!
20630!
20640 Pres_val:!                          ....pressure values
20650      IF Pres_ptr>12 THEN Pres_stl=5
20660      IF Pres_ptr>17 THEN
20670          DISP "Do not input any more pressures;
               disc full"
20680          WAIT 3
20690          SUBEXIT
20700      END IF
20710      PRINT TABXY(9,3);"Time:"
20720      PRINT TABXY(1,4);"Systemic"
20730      PRINT TABXY(4,5);"systolic"
20740      PRINT TABXY(4,6);"diastolic"
20750      PRINT TABXY(4,7);"mean"
20760      PRINT TABXY(1,8);"Pulmonary"
20770      PRINT TABXY(4,9);"systolic"
20780      PRINT TABXY(4,10);"diastolic"
20790      PRINT TABXY(4,11);"mean"
20800      PRINT TABXY(1,12);"LA mean"
20810      PRINT TABXY(1,13);"RA mean"
20820      PRINT TABXY(9,14);"Time: "
20830      PRINT TABXY(1,15);"C.I."
20840      PRINT TABXY(1,16);"PVRI"
20850      PRINT TABXY(1,17);"SVRI"
20860      Start=15
20870      FOR I=Pres_stl TO Pres_ptr
20880          PRINT TABXY(Start,3);Pres_time$(I)
20890          PRINT TABXY(Start,5);Ao_s(I)
20900          PRINT TABXY(Start,6);Ao_d(I)
20910          PRINT TABXY(Start,7);Ao_m(I)
20920          PRINT TABXY(Start,9);Pa_s(I)
20930          PRINT TABXY(Start,10);Pa_d(I)
```

```
20940          PRINT TABXY(Start,11);Pa_m(I)
20950          PRINT TABXY(Start,12);La_m(I)
20960          PRINT TABXY(Start,13);Ra_m(I)
20970          Start=Start+5
20980      NEXT I
20990      Start=15
21000      FOR I=0 TO Heart_ptr
21010          PRINT TABXY(Start,14);Heart_time$(I)
21020          PRINT TABXY(Start,15);Ci(I)
21030          PRINT TABXY(Start,16);Pvri(I)
21040          PRINT TABXY(Start,17);Svri(I)
21050          Start=Start+5
21060      NEXT I
21070      GOTO Finish
21080!
21090!
21100 Drug:!                            ....hey man, drugs
21110      IF Drug_ptr>9 THEN Drug_stl=4
21120      IF Drug_ptr>14 THEN Drug_stl=9
21130      IF Drug_ptr>19 THEN Drug_stl=14
21140      IF Drug_ptr>24 THEN Drug_stl=19
21150      IF Drug_ptr>29 THEN Drug_stl=24
21160      IF Drug_ptr>34 THEN Drug_stl=29
21170      IF Drug_ptr>38 THEN
21180          DISP "do not enter more drugs; disc full"
21190          WAIT 3
21200          SUBEXIT
21210      END IF
21220      PRINT TABXY(30,4);"Drug Chart"
21230      PRINT TABXY(1,6);"Name"
21240      PRINT TABXY(30,6);"Dosage"
21250      PRINT TABXY(60,6);"Time"
21260      D_line=7
21270      FOR I=Drug_stl TO Drug_ptr
21280          PRINT TABXY(1,D_line);Drug_name$(I)
21290          PRINT TABXY(30,D_line);Drug_dos$(I)
```

```
21300           PRINT TABXY(60,D_line);Drug_time$(I)
21310           D_line=D_line+1
21320       NEXT I
21330 Finish: !
21340  SUBEND
21350  !
21360  !
21370  DEF FNLval(Lnum$)
21380      Numval=VAL("9"&Lnum$)
21390      If Num val=9 THEN
21400      Rval=9999.999
21410      RETURN Rval
21420      ELSE
21430      Numval=VAL(Lnum$)
21440      RETURN Numval
21450      END IF
21460      FNEND
```

```
10 Teaser7:!This program reviews data taken by sgrape
20     ! and allows all the graphs to be printed (when
30     ! its done)
40     !
50     !.......................................
60     !
70     ! LAST REVISION: 1 May  1985
80     !........................................
90     !
100    !
110    !........................................
120    !
130    ! SET UP ERROR HANDLERS
140    ! SET UP COMMON STORAGE/ARRAY STORAGE
150    !........................................
160    !
170    !
171     COM /Vars/ Ffthrvar,Fftrespvar
180     COM /Intr_7/ Int_flag,Status_bytes(5)
190     COM /Flags/ Atod_done,Scanner_done,Memory1_
        done,Memory2_done,Timer_done,Counter_done,
          Memory3_done,Memory4_done
200     COM /Io_arrays/ Counters(3),Counters2(3),Time_
        base$[7]
210     COM /Multi_param/ Start_chan,Stop_chan,Pacing_
        bits,Pacing_rate,Num_pts,Num_xfer,
          Num_xfer_left,Name_len,Scr_file$[28],Scr_
           file2$[28]
220     COM /Hr_sig/ Num_pulses,Last_pulse,First_blk_
        flg,Last_time,Num_hr_sig,Max
          _hr_pts,Avg_hr,Rollover,Hr_smooth
230     COM /Hr_stats/ Hr_histo(128),Histo_min,Histo_
        max,Num_fudge,Num_histo_pnts
         ,@Err_log
```

```
240  COM /Plot_par/ Plotbox,Boxcar_flg,Log_
     plotflg,Freq_limit,Resp_search,Pct_thresh
250  COM /Graphs/
     Hrdata(512),Hrspec(512),Respspec(512),Bpspec(512)
260  COM /Vitaldata/ Rfa,Lfa,Peakratio,Meas_resp,Next_
     time
270  COM /Idfield/ Id_field$[18]
280  COM /Messagecom/ Message$(10)[80],@Messages
290  COM /Trends/ Mean_hr_t(60),Lfa_t(60),Rfa_
     t(60),Ratio_t(60),T_ptr,Time_now
        1,Meas_resp_t(60)
300  DIM Msg_pad$(20)[80],Edit_msg$[80]
310  DIM Msg_buffer$[80] BUFFER
320  ASSIGN @Msg_buffer TO BUFFER Msg_buffer$
330  Log_plotflg=0
340  Freq_limit=1.
350  Resp_search=.1
360  Pct_thresh=.2
370  Scr_file$="?"
380  !
390  ! Set up common/array storage for waveform
       analysis
400  !
410  !..............................................
420  !
430  ! Set up common/array storage for waveform
     ! analysis
440  !..............................................

450  !
460  COM /Directory/ Dir$[160],@Printer
470  COM /Wf1/ Printer,Plotter,String$[40]
480  COM /Wf2/ Signal(8257),Number_pnts,Type,Sampling_
     period
490  COM /Wf3/ Segment_size,Overlap,Num_segments,Pnts_
     used,Fft_size
```

```
500    COM /Wf5/ Refn(63),Refd(63),Refno,Refdo,Refgain
510    COM /Autoparam/ Up_down,Up_delay,Dn_delay
520    COM /Fftcom/ INTEGER Bitrev(512),Sincos(512)
530   !
540    DISP "loading subroutines"
550    LOADSUB ALL FROM "hr_siggen8"
560    LOADSUB ALL FROM "automaxsb2"
570    LOADSUB ALL FROM "fft_anal6"
580    DISP "load data disks and press CONTINUE"
590    PAUSE
600   !
610   !...............................................
620   ! The HP 9826/9836 flexible disk (5-1/4") has the
        following structure
630   !  2 sides, 33 tracks/side, 16 sectors/track, 256
         bytes/sector
640   !   1 track  =   4096 bytes =   16 sectors
650   !   1 side   = 135168 bytes =  528 sectors
660   !   1 disk   = 270336 bytes = 1056 sectors
670   !   1 disk   = 135168 words = 132K words
680   !................................................

690   !
700   !
710    INTEGER Hpib_buffer1(2048) BUFFER
720    INTEGER Hpib_buffer2(2048) BUFFER
730    DIM Hr_signal(1024) BUFFER
740    Read_ptr1=0
750    Read_ptr2=0
760 Begin: !
770 Selections: !
780   !
790   !
800   ! NOW SET UP THE SCAN CARD PARAMETERS (DEFAULT
      ! VALUES)
810   !     START CHANNEL (3.0) -  0
```

```
820  !       STOP CHANNEL (3.1) -  1
830  !             PACING (3.2) - 40 USEC
840  !         SEQN'L SCAN (3.3) - XXXX XXXX XXX1 (   1)
850  !       INTN'L PACING (3.3) - XXXX XXXX X1XX (   4)
860  !       MSEC TIMEBASE (3.3) - XXX1 XXXX XXXX (256)
870  !
880  CALL Get_param
890  !
900  ! set up the bit reverse index
910  !
920  Npair=Num_pts/2
930  K=0
940  FOR J=1 TO Npair-1
950      I=2
960      Ndivi=Npair/I
970      IF K<Ndivi THEN 1010
980      K=K-Ndivi
990      I=I+I
1000     GOTO 960
1010     K=K+Ndivi
1020     Bitrev(J+1)=K+1
1030 NEXT J
1040 !
1050 ! set up the sin/cosine table
1060 !
1070 Angl=ATN(1)*8/Npair
1080 FOR J=0 TO Npair-1
1090     Sincos(J)=SIN(Angl*J)
1100 NEXT J
1110 !
1120 ! set up other data  paths
1130 !
1140 ! ASSIGN @Err_log TO "errs"&Id_
          field$&":HP8290X,700,1";FORMAT OFF
1150 ! ASSIGN @Messages TO "msgs"&Id_
          field$&":HP8290X,700,1";FORMAT OFF
```

```
1160 ! ASSIGN @Temp_trend TO "trnd"&Id_
       field$&":HP8290X,700,1";FORMAT OFF
1170   IF Num_pts=0 THEN GOTO Begin
1180   Read_ptr1=0
1190 Setup_scan:DISP " NUMBER OF POINTS=";Num_pts
1200   Read_ptr1=0
1210   Read_ptr2=0
1220 Setup_counter:!
1230 Setup_clock:!
1240   Block_time=Pacing_rate*1.024
1250   First_blk_flg=1
1260   Num_msgs=0
1270   Message_line=0
1280   Msg_dp_request=0
1290   Resp_dpflg=0
1300   Max_hr_pts=1024
1310   Last_time=0
1320 !
1330 ! setup control parameters
1340 !
1350 Defaultset:!
1360   INPUT "use default settings?",Resp$
1370   IF Resp$="N" THEN Frqlimset
1380   Freq_limit=2.
1390   Pct_thresh=.2
1400   Resp_dpflg=1
1410   Resp_search=.2
1420   Hcdopyflg=0
1430   PRINT "Spectra displayed to";Freq_limit;"Hz"
1440   PRINT "resp peak search threshold=";Pct_thresh
1450   PRINT "resp series plot w/hr series"
1460   PRINT "resp peak search starts at";Resp_
       search;"Hz"
1470   PRINT "no hard copy will be printed"
1480   INPUT "is this ok?",Resp$
1490   IF Resp$<>"Y" THEN Defaultset
```

```
1500   GOTO Skipset
1510 Frqlimset:!
1520   INPUT "frequency limit?",Freq_limit   !..change
       spectra disp.freq.range
1530   IF Freq_limit<>1. THEN Freq_limit=2.
1540   PRINT "Spectra displayed to";Freq_limit;"Hz"
1550   INPUT "is this ok?",Resp$
1560   IF Resp$<>"Y" THEN Frqlimset
1570 Searchset:!
1580   INPUT "resp peak threshold?",Pct_thresh !..change
       peak search threshold
1590   IF Pct_thresh>.8 THEN Pct_thresh=.2
1600   PRINT "resp peak search threshold=";Pct_thresh
1610   INPUT "is this ok?",Resp$
1620   IF Resp$<>"Y" THEN Searchset
1630 Respdpset:!
1640   INPUT "display resp time series?",Resp$
            !..display respiration time series
1650   IF Resp$<>"N" THEN
1660       Resp_dpflg=1
1670       PRINT "resp series plot w/hr series"
1680   ELSE
1690       Resp_dpflg=0
1700       PRINT "cancel resp series plot"
1710   END IF
1720   INPUT "is this ok?",Resp$
1730   IF Resp$<>"Y" THEN Respdpset
1740 Resppkset: !
1750   INPUT "start for resp peak search?",Resp_
       search    !..change respiration
                     peak search
1760   IF Resp_search>Freq_limit-.1 THEN Resp_search=.1
1770   PRINT "resp peak search starts at";Resp_
       search;"Hz"
1780   INPUT "is this ok?",Resp$
1790   IF Resp$<>"Y" THEN Resppkset
```

```
1800 Hdcopyset: !
1810   INPUT "print hardcopy?",Resp$
1820   IF Resp$="N" THEN
1830       Hdcopyflg=0
1840       PRINT "no hard copy will be printed"
1850   ELSE
1860       Hdcopyflg=1
1870       PRINT "hard copy will be printed"
1880   END IF
1890   INPUT "is this ok?",Resp$
1900   IF Resp$<>"Y" THEN Hdcopyset
1910 Skipset:  !
1920  !
1930  ! Read data continuously
1940  !
1950  ! Set up the memory buffers and disk files
1960  !
1970 Reading:  !
1980   ASSIGN @In_buffer TO BUFFER Hpib_buffer1(*)
1990   ASSIGN @Diskbuffer TO Scr_file$;FORMAT OFF
2000   ASSIGN @In_buffer2 TO BUFFER Hpib_buffer2(*)
2010   ASSIGN @Diskbuffer2 TO Scr_file2$;FORMAT OFF
2020  !
2030   Data_lockout=0
2040 !
2050 ! generate id fields to identify data files
2060 !........................................
2070 ! the first 256 bytes of the file are reserved for
       identification
2080 !
2090 ! the reserved data are:
2100 !    byte   1 - 72 ("H") or 82 ("R"): hr or resp_
     !    file
2110 !    byte   2 - year (at beginnig of expt.)
2120 !    byte   3 - month
2130 !    byte   4 - day
```

```
2140 !    byte   5 - hour
2150 !    byte   6 - minute
2160 !    byte   7 - collecting program date (0-365)
2170 !    byte   8 - collecting program year (1984-?)
2180 !    byte   9-16: unused
2190 !    byte  17 - pacing rate (0-32768)
2200 !    byte  18 - pacing rate units(77 ="M" or 85
     !    ="U")
2210 !    byte  19 - number of transfers
2220 !    byte  20 - number of point/transfer (=1024)
2230 !    byte  21 - number of A/D channels used (=1)
2240 !    byte  22-256 : unassigned
2250 !
2260 !    the remainder of the file is data
2270 !    each transfer is preceded by an identifying
     !    string of 8 bytes
2280 !    byte 1 - time of day (timedate mod 86400)/60
2290 !    byte 2 - number of points in next transfer
2300 !    byte 3 - H/R (check to make sure this is the
          right file)
2310 !.................................................
2320 !
2330 ! INTEGER Id_buffer(255) BUFFER
2340   Time_now=TIMEDATE
2350 ! Id_buffer(0)=72                 !..Heart rate file
2360   Date_now$=DATE$(TIMEDATE)
2370 ! Day_now=VAL(Date_now$)
2380 ! Year_now=VAL(Date_now$[8;4])
2390 ! Month_now=FNMonth(Date_now$)
2400 ! Id_buffer(1)=Year_now                      !..year
2410 ! Id_buffer(2)=Month_now                    !..month
2420 ! Id_buffer(3)=Day_now                        !..day
2430   Time_now1=Time_now MOD 86400
2440 ! Id_buffer(4)=Time_now1/3600                !..hour
2450 ! Id_buffer(5)=(Time_now1 MOD 3600)/60       !..min
2460 ! Id_buffer(6)=348                      !..pgm date
```

```
2470 ! Id_buffer(7)=1984                          !..pgm year
2480 ! Id_buffer(16)=Pacing_rate
2490 ! Id_buffer(17)=77                             !..MSEC
2500 ! Id_buffer(18)=Num_xfer
2510 ! Id_buffer(19)=1024                          !..num_pts
2520 ! Id_buffer(20)=1                           !..# channels
2530 !
2540 !
2550 ! read id field for heart rate file
2560 !
2570 ! ASSIGN @Id_buffer TO BUFFER Id_buffer(*)
2580 ! TRANSFER @Diskbuffer2 TO @Id_buffer;COUNT
     ! 256,WAIT
2590 ! ASSIGN @Id_buffer TO *
2600 !
2610 ! read id field for respiratory file
2620 !
2630 ! Id_buffer(0)=82                        !..Resp file
2640 ! ASSIGN @Id_buffer TO BUFFER Id_buffer(*)
2650 ! TRANSFER @Diskbuffer TO @Id_buffer;COUNT 256,WAIT
2660 ! ASSIGN @Id_buffer TO *
2670 !
2680 !
2690 !
2700 ! begin transferring data from the A/D buffer
2710 !
2720 Blk_xfer:!
2730   CONTROL @In_buffer,3;1
     ! Reset fill pointer for buffer
2740   CONTROL @In_buffer,4;0
     ! Reset current number of bytes in buffer
2750   CONTROL @In_buffer,5;1
     ! Reset empty pointer for buffer
2760  !
2770  ! read an 8 byte sequence to disk as a header for
      ! the transfer
```

```
2780  !
2790   CALL Rdheader(@Diskbuffer,Num_pts,"R")
2800  !
2810   Num_rdpts=Num_pts
2820   TRANSFER @Diskbuffer TO @In_buffer;COUNT Num_
       rdpts*2,CONT
2830   PRINT TABXY(1,18);
2840   PRINT USING Image_wtl;Num_xfer-Num_xfer_
       left+1,Num_xfer,TIME$(Next_time),
Rdseg,Num_rdseg
2850 Image_wtl:IMAGE    "Next xfer(",K,"/",K,"): ",K,"
                         seg=",K,"/",K
2860  !
2870  ! store A/D buffer on complete data file (also
        save pointers for heart rate)
2880  !
2890  !
2900 Resume1:!
2910   Next_time=Next_time+INT(Block_time)
2920  !
2930  !
2940  !
2950 Resume2:!
2960   Num_xfer_left=Num_xfer_left-1
2970   CONTROL @In_buffer2,3;1
     ! Reset fill pointer for buffer
2980   CONTROL @In_buffer2,4;0
     ! Reset current number of bytes in buffer
2990   CONTROL @In_buffer2,5;1
     ! Reset empty pointer for buffer
3000  !
3010  ! read an 8 byte sequence to disk as a header for
      ! the transfer
3020  !
3030   CALL Rdheader(@Diskbuffer2,Num_pulses,"H")
3040   TRANSFER @Diskbuffer2 TO @In_buffer2;COUNT Num_
```

```
        pulses*2,WAIT
3050  !
3060 Resume5:!
3070   Histo_max=8000
3080   Histo_min=-8000
3090   CALL Hr_sig_gen(Hpib_buffer2(*),Hr_signal(*))
3100  !
3110  !
3120 Resume6:!
3130   OUTPUT 2;CHR$(255)&CHR$(75);
      ! Clear CRT of text
3140   GINIT
3150   PLOTTER IS 3,"INTERNAL"
3160   GRAPHICS ON
3170   Xscale=8
3180   Hr_max=MAX(Hr_signal(*))
3190   Hr_min=MIN(Hr_signal(*))
3200   VIEWPORT 0,64,50,100
3210   WINDOW 0,1,0,1
3220   AXES .1,.1,0,0
3230   CSIZE 4
3240   Hr_signal(1024)=0
3250   Hr_sigsum=SUM(Hr_signal)
3260   Mean_hr=INT((Hr_sigsum/1024+Avg_hr))
3270   LDIR 0
3280   LORG 3
3290   MOVE .2,.9
3300   LABEL "HR data   hr=";Mean_hr
3310   CSIZE 4
3320   MOVE .05,1
3330   LORG 3
3340   LABEL "250 bpm"
3350   WINDOW 1,0,1,0
3360   AXES 0,0,0,0
3370   IF Hr_dispflg=1 THEN
3380       WINDOW 0,1024,Hr_min,Hr_max
```

```
3390   ELSE
3400       Low_window=INT(-Avg_hr)
3410       High_window=Low_window+250.
3420       WINDOW 0,1024,Low_window,High_window
3430   END IF
3440   FOR I=0 TO 1023
3450       PLOT I,Hr_signal(I)
3460   NEXT I
3470  !CALL Pauser
3480   IF Fftskpflg=1 THEN GOTO Skip_fft
3490  !
3500  ! display respirations time series also
3510  !
3520   IF Resp_dpflg=1 THEN
3530       Max_resp=MAX(Hpib_buffer1(*))
3540       Min_resp=MIN(Hpib_buffer1(*))
3550       IF Mean_hr>100 THEN
3560           VIEWPORT 0,64,50,65
3570       ELSE
3580           VIEWPORT 0,64,75,90
3590       END IF
3600       WINDOW 0,1023,Min_resp,Max_resp
3610       MOVE 0,Hpib_buffer1(0)
3620       FOR I=1 TO 1023
3630           PLOT I,Hpib_buffer1(I)
3640       NEXT I
3650   ELSE
3660       Resp_dpflg=0
3670   END IF
3680  !
3690  ! now process heart rate data with waveform
        analysis package
3700  ! make sure the hr_signal has zero mean
3710  !
3711  MAT Signal= (0)
3720   Hr_bias=Hr_sigsum/1024
```

```
3730   FOR I=0 TO 1023
3740       Signal(I)=Hr_signal(I)-Hr_bias
3750   NEXT I
3751   Hr_var=DOT(Signal,Signal)/1024
3760   Plotbox=2
3770   DISP "HR fft in process"
3780   CALL Wf_analyzer(Pacing_rate)
3790  !
3800  ! now process respiration data with waveform
        analysis package
3810  !
3820   MAT Signal= (0)
3830   FOR I=0 TO 1023
3840       Signal(I)=Hpib_buffer1(I)
3850   NEXT I
3860   Signal_avg=SUM(Signal)/1024.
3870   MAT Signal= Signal-(Signal_avg)
3880   Plotbox=4
3881   Respvar=DOT(Signal,Signal)/1024
3890   DISP "RESP fft in process"
3900   CALL Wf_analyzer(Pacing_rate)
3901   PRINT "hr_var,respvar";Hr_var;Respvar
3902   PRINT "fft vars: ";Ffthrvar,Fftrespvar
3910   Trend_dp=0 !..trend graph not displayed
3920  !
3930  ! waveform analysis completed, compile trends and
        store in temporary file
3940  !
3950   Mean_hr_t(T_ptr)=Mean_hr
3960   Lfa_t(T_ptr)=Lfa
3970   Rfa_t(T_ptr)=Rfa
3980   Ratio_t(T_ptr)=Peakratio
3990   Meas_resp_t(T_ptr)=Meas_resp
4000   T_ptr=T_ptr+1
4010   IF Hdcopyflg=1 THEN
4011       DUMP DEVICE IS 701
```

```
4020         DUMP GRAPHICS
4030         PRINTER IS 701
4040         PRINT "hr=";Mean_hr
4050         PRINT "lfa=";Lfa
4060         PRINT "rfa=";Rfa
4070         PRINT "ratio";Peakratio
4080         PRINT "RR";Meas_resp
4090         PRINT "transfer#";T_ptr
4091         PRINT "hr_var,respvar";Hr_var;Respvar
4092         PRINT "fft vars: ";Ffthrvar,Fftrespvar
4100         PRINTER IS 1
4110     END IF
4120   !
4130   ! continue with data collection
4140   !
4150 Skip_fft: !
4160     IF Num_xfer_left<=0 THEN
4170         GOTO Eo_blk_xfer
4180     ELSE
4190         DISP Num_xfer_left;"transfers remaining"
4200         WAIT 3
4210         GOTO Blk_xfer
4220     END IF
4230 Eo_blk_xfer:End_time=TIMEDATE
4240     Delta_time=End_time-Start_time
4250     !
4260     Stop_pacing=TIMEDATE
4270 !
4280 Aborter:!
4290     ASSIGN @In_buffer TO *
4300     ASSIGN @In_buffer2 TO *
4310     ASSIGN @Diskbuffer TO *
4320     ASSIGN @Diskbuffer2 TO *
4330 !   ASSIGN @Err_log TO *
4340 !   ASSIGN @Messages TO *
4350 !   ASSIGN @Temp_trend TO *
```

```
4360   CALL Pauser
4370   GRAPHICS OFF
4380   CALL Get_param
4390 ! ASSIGN @Err_log TO "errs"&Id_
       field$&":HP8290X,700,1";FORMAT OFF
4400 ! ASSIGN @Messages TO "msgs"&Id_
       field$&":HP8290X,700,1";FORMAT OFF
4410   IF Num_pts=0 THEN GOTO Begin
4420   GOTO Setup_scan
4430   END
4440   !
4450   !
4460   !
4470   !
4480   !
4490   SUB Pauser
4500       DISP "press CONTINUE to continue"
4510       PAUSE
4520       DISP
4530   SUBEND
4540   !
4550   !
4560   !
4570   !
4580   !
4590   SUB Get_param
4600       COM /Multi_param/ Start_chan,Stop_chan,Pacing_
           bits,Pacing_rate,Num_pt
           s,Num_xfer,Num_xfer_left,Name_len,Scr_
           file$[28],Scr_
           file2$[28]
4610       COM /Trends/ Mean_hr_t(*),Lfa_t(*),Rfa_
           t(*),Ratio_t(*),T_ptr,Time_now
             1,Meas_resp_t(*)
4620       COM /Vitaldata/ Rfa,Lfa,Peakratio,Meas_
           resp,Next_time
```

```
4630        COM /Idfield/ Id_field$
4640        DIM Mo$[24]
4650        Mo$="JAFBMRAPMYJNJLAUSPOCNODC"
4660        INTEGER Id_buffer(255) BUFFER
4670        Disk_name$=":HP8290X,700,1"
4680 Oldmsg:PRINT CHR$(12)
4690 !
4700 !
4710 Ch_sel:!
4720        Start_chan=0
4730        Stop_chan=0
4740  !
4750        Pacing_bits=0
4760 Pacing_sel:!
4770        Base$="M"
4780        Pacing_bits=261
4790  !
4800        Base$=Base$&"SEC"
4810  !
4820  !
4830  ! FINDOUT BLOCKSIZE FOR DATA TRANSFER
4840  !
4850 Get_xfer:DISP "Enter number of transfers: (0 -
        change scan, <0 - quit)"
4860        OUTPUT 2;55;
4870        ENTER 2;Num_xfer
4880        IF Num_xfer<0 THEN     !..terminate program
4890            INPUT "to lose trend data type
            'lose'",Response$
4900            IF Response$<>"lose" THEN
4910                CREATE BDAT
                "teasertrnd:HP8290X,700,1",19,256
4920                ASSIGN @Trndfile TO
                "teasertrnd:HP8290X,700,1";FORMAT OFF
4930                OUTPUT @Trndfile;Mean_hr_t(*),Lfa_
                t(*),Rfa_t(*),Ratio_t(*),Me
```

```
                        as_resp_t(*),T_ptr
4940                ASSIGN @Trndfile TO *
4950            END IF
4960            DISP "PROGRAM COMPLETED"
4970            STOP
4980        END IF
4990        IF Num_xfer=0 THEN
5000            Num_pts=0
5010            SUBEXIT
5020        END IF
5030 !
5040 ! since new data is to be taken, zero the trend
       graphs (120 pts=8hrs)
5050 !
5060        MAT Mean_hr_t= (0)
5070        MAT Rfa_t= (0)
5080        MAT Lfa_t= (0)
5090        MAT Ratio_t= (0)
5100        MAT Meas_resp_t= (0)
5110        T_ptr=0
5120        Ratio_t(0)=1 !..prevent trend graph errors on
            startup
5130        Rfa=0
5140        Lfa=0
5150        Meas_resp=0
5160        Peakratio=1
5170 !
5180 Intvl_sel:DISP "ENTER PACING RATE (IN
      ";Base$[1,4];"):"
5190        OUTPUT 2;250;
5200        ENTER 2;Pacing_rate
5210        IF Pacing_rate<0 OR Pacing_rate>65535 THEN
            GOTO Intvl_sel
5220  !
5230        Num_pts=1024*Num_xfer
5240        Num_header=256+8*Num_xfer
```

```
5250        INPUT "type in date on which data was
            taken",Datdate$
5251        INPUT "is trend file named 'trnd' (1) or
            'temp_trend' (2)?",File_nm
5260        Datdate$=DATE$(DATE(Datdate$))
5270 !
5280 ! the data files are named according to the date
5290 ! in the following format:
5300 !      xxxxmmddyy
5310 ! where
5320 !      xxxx - resp,hr__,msgs,errs,trnd
5330 !      dd   - day
5340 !      mm   - month
            (JA,FB,MR,AP,MY,JN,JL,AU,SP,OC,NO,DC)
5350 !      yy   - year
5360        Month_now=FNMonth(Datdate$)*2-1
5370        Mm$=Mo$[Month_now;2]
5380        Id_field$=Datdate$[1;2]&Mm$&Datdate$[10;2]
5390 ! new name for respiratory file: respddmmyy
5391 IF File_nm=1 THEN
5400        Scr_file$="resp"&Id_field$&Disk_name$
5410 ! new name for heart rate file: hr__ddmmyy
5420        Scr_file2$="hr__"&Id_field$&Disk_name$
5421        ELSE
5422            Scr_file$="AOK"&Disk_name$
5423            Scr_file2$="hrAOK"&Disk_name$
5424            END IF
5430 ! new name for errorlog: errsddmmyy
5440 ! new name for message log: msgsddmmyy
5450 ! name for trend summary file: trndddmmyy
5460        Num_rec=-INT(-(Num_pts+Num_header)/128.)
5470        Num_pts=1024
5480        PRINT Num_pts*Num_xfer;"points were
            transferred in";Num_xfer;"blocks
             of";Num_pts;"points"
5490   !
```

```
5500        Num_xfer_left=Num_xfer
5510    SUBEND
5520    !
5530    !
5540    !
5550    !
5560    DEF FNMonth(Date_now$)
5570        Month$=Date_now$[4;3]
5580        Month=0
5590        IF Month$="Jan" THEN Month=1
5600        IF Month$="Feb" THEN Month=2
5610        IF Month$="Mar" THEN Month=3
5620        IF Month$="Apr" THEN Month=4
5630        IF Month$="May" THEN Month=5
5640        IF Month$="Jun" THEN Month=6
5650        IF Month$="Jul" THEN Month=7
5660        IF Month$="Aug" THEN Month=8
5670        IF Month$="Sep" THEN Month=9
5680        IF Month$="Oct" THEN Month=10
5690        IF Month$="Nov" THEN Month=11
5700        IF Month$="Dec" THEN Month=12
5710        RETURN Month
5720    FNEND
5730 !
5740 !
5750 !
5760 !
5770 !
5780    SUB Rdheader(@Disk,Num_bytes,File_id$)
5790        INTEGER Xheader(7) BUFFER
5800        ASSIGN @Xheader TO BUFFER Xheader(*)
5810        TRANSFER @Disk TO @Xheader;COUNT 16,WAIT
5820        ASSIGN @Xheader TO *
5830        Num_bytes=Xheader(1)
5840        File_id$=CHR$(Xheader(2))
5850    SUBEND
```

```
5860 !
5870 !
5880 !
5890 !
5900 !
5910 !
5920  SUB Trend_graph
5930 !
5940      COM /Trends/ Mean_hr_t(*),Lfa_t(*),Rfa_
          t(*),Ratio_t(*),T_ptr,Time_now
            1,Meas_resp_t(*)
5950      COM /Multi_param/ Start_chan,Stop_chan,Pacing_
          bits,Pacing_rate,Num_pt
          s,Num_xfer,Num_xfer_left,Name_len,Scr_
            file$[28],Scr_
          file2$[28]
5960      Block_time=Pacing_rate*1.024/3600.
5970      GINIT
5980      GCLEAR
5990      PRINT CHR$(12)
6000      GRAPHICS ON
6010      PRINT TABXY(1,18);"trend graph"
6020      Beg_time=Time_now1/3600-Block_time
6030      End_time=Beg_time+Num_xfer*Block_time
6040      Ibeg_time=INT(Beg_time)
6050      IF Ibeg_time<Beg_time THEN Ibeg_time=Ibeg_
          time+1
6060 !
6070 ! label the time axes
6080 !
6090      VIEWPORT 0,128,45,50
6100      WINDOW Beg_time,End_time,0,1
6110      IF INT(End_time)>Beg_time THEN
6120          LDIR 0
6130          FOR T_label=Ibeg_time TO INT(End_time)
6140              MOVE T_label,.5
```

```
6150                 LORG 5
6160                 CSIZE 4
6170                 LABEL T_label
6180             NEXT T_label
6190         END IF
6200         VIEWPORT 0,128,40,45
6210         WINDOW 0,1,0,1
6220         MOVE .5,0
6230         LORG 4
6240         LABEL "Time (24 hr)"
6250 !
6260 ! draw the axes
6270 !
6280         VIEWPORT 0,128,50,100
6290         WINDOW Beg_time,End_time,0,1
6300         AXES 1/15.,.1,Beg_time,0
6310         WINDOW 1,0,1,0
6320         AXES 0,.25,0,0
6330 !
6340 ! mean heart rate trends
6350 !
6360         WINDOW -1,Num_xfer,0,200.
6370         MOVE 0,Mean_hr_t(0)
6380         FOR I=0 TO T_ptr-1
6390             DRAW I,Mean_hr_t(I)
6400         NEXT I
6410 !
6420 ! lfa trends
6430 !
6440         WINDOW -1,Num_xfer,0,10.
6450         LINE TYPE 4,5
6460         MOVE 0,Lfa_t(0)
6470         FOR I=0 TO T_ptr-1
6480             DRAW I,Lfa_t(I)
6490         NEXT I
6500 !
```

```
6510 ! rfa trends
6520 !
6530       WINDOW -1,Num_xfer,0,10.
6540       LINE TYPE 5,5
6550       MOVE 0,Rfa_t(0)
6560       FOR I=0 TO T_ptr-1
6570           DRAW I,Rfa_t(I)
6580       NEXT I
6590 !
6600 ! ratio trends (with a line at ratio=2)
6610 !
6620       WINDOW -1,Num_xfer,-2.5,2.5
6630       LINE TYPE 8,5
6640       MOVE 0,LGT(Ratio_t(0))
6650       FOR I=0 TO T_ptr-1
6660           DRAW I,LGT(Ratio_t(I))
6670       NEXT I
6680       LINE TYPE 3,5 !..sparsely dotted line at
           ratio=2
6690       MOVE 0,LGT(2.)
6700       DRAW T_ptr-1,LGT(2.)
6710 !
6720 ! respiration trends
6730 !
6740       WINDOW -1,Num_xfer,0,200
6750       LINE TYPE 5,10
6760       MOVE 0,Meas_resp_t(0)
6770       FOR I=0 TO T_ptr-1
6780           DRAW I,Meas_resp_t(I)
6790       NEXT I
6800 !
6810 ! draw a key for line types
6820 !
6830       VIEWPORT 64,128,0,50
6840       WINDOW 0,1,0,13
6850       PRINT TABXY(55,15);"mean hr(0-200)"
```

```
6860      PRINT TABXY(55,16);"lfa    (0-10)"
6870      PRINT TABXY(55,17);"rfa    (0-10)"
6880      PRINT TABXY(55,18);"ratio(.01-100)"
6890      LINE TYPE 1,5
6900      MOVE .8,11
6910      DRAW 1.,11
6920      LINE TYPE 4,5
6930      MOVE .8,10
6940      DRAW 1.,10
6950      LINE TYPE 5,5
6960      MOVE .8,9
6970      DRAW 1.,9
6980      LINE TYPE 8,5
6990      MOVE .8,8
7000      DRAW 1.,8
7010      LINE TYPE 1,5
7020   SUBEND
```

```
' CALIB - program to calibrate instruments using
    board#1
' last revision:  4 April 1985


defint a-y          ' only z denotes a real number
dim buffer(12800)
hrbpm=0
zfqlow=0.
zfqres=0.
zlfa=0.
zrfa=0.
cls


'define ports on 8253
timer0=&h720
timer1=&h721
timer2=&h722
con8253=&h723


' set timer modes to 16 bit square wave rate
    generators
out con8253,&h36
out con8253,&h76
out con8253,&hB6

'for testing set timer 0 to 100Hz timebase
'2.38MHz/23864: 23864=93*256+56
'set timer 0 to 1280Hz timebase
'(2.38MHz/1864) (1864=7*256+72)
'set timer 1 as a 1Hz clock at startup
'(gives a heart rate signal at
```

```
'60bpm) 'set timer 2 as a flip flop
        out timer0,56
        out timer0,93
        out timer0,72
        out timer0,7
        out timer1,0
        out timer1,5
        hrbpm=60
        out timer2,2
        out timer2,0


        ' turn the gates on using the 8255 at bits 0,1,2
on portc
        porta=&H700
        portb=&H708
        portc=&H710
        con8255=&H718

        ' first set all 8255 ports to output, then set
portc to 0FFH
        out con8255,128
        out portc,&H0FF



        ' first print out the present value of the
interrupt vectors
        locate 4,1
        gosub 10000


        ' install the interrupt with a dummy buffer and
            print vectors
        reseter=256
        call wrbuffer(reseter)
```

```
          reseter=128
          call wrbuffer(reseter)
          call instint
          locate 5,1
          gosub 10000


          ' now go through required startup subroutines
          gosub 90                   ' set up breathing
signal
          gosub 70                   ' set up heart rate
variations
          gosub 50                   ' put some information
on screen
          gosub 80                   ' turn D/A on
          locate 1,1
          print "commands: h(rvar),i(nt
on),q(uit),r(beats),b(reath),c(ounts)"


          ' wait until user hits a key
          savekey$=""
40        while
len(savekey$)=0:savekey$=savekey$+inkey$:wend
          if savekey$="r" then gosub 50   'print heart
beats
          if savekey$="q" then goto 9996  'quit
          if savekey$="c" then gosub 60   'print timers
          if savekey$="h" then gosub 70   'set up heart
rate
          ' variations
          if savekey$="i" then gosub 80   'unmask
interrupts
          if savekey$="b" then gosub 90   'set up
breathing signal
          savekey$=""
```

```
        goto 40

        'print present value of heartbeats

50      locate 7,1
        call rdbeat(n)
        print "present heart beats are: ";n;time$
        return


        ' print present value of counters
60      out control,0            'latch timer0
        tlow0=inp(timer0)
        thigh0=inp(timer0)
        out control,&h40         'latch timer1
        tlow1=inp(timer1)
        thigh1=inp(timer1)
        out control,&h80         'latch timer2
        tlow2=inp(timer2)
        thigh2=inp(timer2)
        locate 8,1
        print "timer0: ";tlow0+thigh0*16;tab(20);"
timer1:
          ";tlow1+thigh1*16;
        print tab(40);"timer2: ";tlow2+thigh2*16
        return



        ' set up the heart rate variations
        '       respiratory frequency is given by
1280Hz/buffer
        '          length
        '       low frequency is 1280Hz/low frequency
divider
        '
```

```
70      if numval<=0 then beep:print "setup analog
buffer
           first":return
71      locate 17,1
        print "present lfa,rfa(bpm)= ";zlfa,zrfa,"at
freqs(Hz):
              ";zfqlow,zfqres
        input "lfa,rfa,low freq: ",zlfan,zrfan,zfqlown
        if zlfan>30. then beep:goto 71 else zlfa=zlfan
        if zrfan>30. then beep:goto 71 else zrfa=zrfan
        if zfqlown<.02 or zfrlown>zfqres then beep:goto
71 else
           zfqlow=zfqlown
        locate 21,1
        print "mean heart rate(bpm)= ";hrbpm
72      locate 22,1
        input "new mean heart rate(bpm): .",newhrbpm
        if newhrbpm>150 or newhrbpm<30 then beep:goto 72
else
           hrbpm=newhrbpm
                'clear screen after input
        locate 17,1
        print space$(72)
        print space$(72)
        print space$(72)
        print space$(72)
        print space$(72)


        ' now compute values for hrsetup subroutine
        meandiv=76800#/hrbpm    '1280*60 ticks/min gives
           ticks/beat
        rfascal=76800#/(hrbpm-zrfa)-76800#/(hrbpm+zrfa)
                       ' rfascal is the total excursion
of
                       ' respiration
```

```
        lfascal=76800#/(hrbpm-zlfa)-76800#/(hrbpm+zlfa)
                        ' lfascal is the total excursion
                          of low frequency
        lowdiv=meandiv-(rfascal+lfascal)/2#

        tbaserst=1280#/zfqlow
        locate 17,1
        print "tbaserst,rfascal,lfascal,lowdiv:
              ";tbaserst;rfascal;lfascal;
        print lowdiv
        call hrsetup(tbaserst,rfascal,lfascal,lowdiv)

        return



        ' print out interrupt controller parameters
80      locate 10,1
        mask=inp(&h21)
        if (mask mod 16)<8 then mask=mask+8 else
mask=mask-8
        out &h21,mask
        mask=inp(&h21)
        print "8259 IMR(interrupt mask regsiter)=
";mask;"
             =";hex$(mask)
        return



        ' this subroutine will change the analog buffer
90      locate 12,1
        input "enter breathing rate (bpm): ",brate
        if brate>75 or brate<7 then beep:goto 90
        zfqres=brate/60#
        numval=76800#/brate
```

```
        ztincr=8*ATN(1#)/numval
        locate 12,40
        color 31:print "calculating respiratory
signal...":color 7
        call exstint          ' turn off interrupts
                                 while resetting buffer
        reseter=256
        call wrbuffer(reseter)
        for itime=0 to numval
            ztnow=ztnow+ztincr
            analogval=127*(1#+SIN(ztnow))
            call wrbuffer(analogval)
        next itime
        call instint
        locate 12,40
        print "respiratory signal active now      "
        return


        ' exstall the interrupt and print vector
9996    cls
        locate 4,1
        gosub 10000
        call exstint
        locate 5,1
        gosub 10000
        locate 21,1
9999    stop

        ' subroutine to print out the interrupt vectors

10000   def seg=0
        print "IRQ3 @0B*4H: ";hex$(peek(&h2C));"
             ";hex$(peek(&h2D));" ";
```

```
        print hex$(peek(&h2E));"
";hex$(peek(&h2F));tab(40);
        print "IRQ4 @0C*4H: ";hex$(peek(&h30));"
              ";hex$(peek(&h31));" ";
        print hex$(peek(&h32));" ";hex$(peek(&h33))
        return

        end
```

```
                page    66,80
; bdzint.asm - an assembler routine to handle interrupts
;               from IRQ3
; Last.revision:  1 April 1985
;
;
                ;-------------------------------;
                ;  8088 interrupt location      ;
                ;-------------------------------;

abs0            segment at 0    ;absolute memory segment
                                ;allows placement of
                                ;interrupt address
                                ;future timebase
                                ;  interrupt handler
                                ;  resides at int 0B
IRQ3_int        dw      2 dup(?);offset value is a word

                org     0CH*4   ;heart beat interrupt
                                ;handler resides at int
                                ; 0C
IRQ4_int        dw      2 dup(?);offset value is a word

abs0            ends            ;


                ;-------------------------------;
                ; int_buffer: area to save DOS  ;
                ;      dummy interrupt ptr      ;
                ;-------------------------------;


int_buffer      segment         ;data segment containing
                                ;user interrupt buffer
save_int        dw      4 dup(?);offset for two DOS
```

```
                                        ;interrupts saved
                                        ;to be restored using
                                        ;exstint

int_buffer      ends                    ;


                        ;-------------------------;
                        ; working storage for     ;
                        ; time base interrupts    ;
                        ;-------------------------;


dseg_tbase      segment             ;data segment for timebase
                                    ; interrupt
heartbeats      dw          ?       ;keep track of heart beats
                                    ; here (for debugging)
base_rate       dw          ?       ;lowest divisor for heart
                                    ; rate
lfa_scal        db          ?       ;low frequency modulation
rfa_scal        db          ?       ;high frequency modulation
tbase_ctr       dw          ?       ;counter for timebase
                                    ; interrupt
                                    ;(use for low frequency
                                    ;  generation)
tbase_rst       dw          ?       ;reset value for tbase_ctr
                                    ; used to set low frequency
tbase_ptr       dw          ?       ;pointer to present analog
                                    ; value
tbase_len       dw          ?       ;length of analog data buffer
tbase_buffer db  2800dup(?)  ;buffer for A/D values
dseg_tbase      ends                ;
```

```
                  ;-------------------------------------;
                  ; setup structures to allow access to;
                  ; arguments pased by BASIC           ;
                  ;-------------------------------------;


                  ; subroutine rdbeat(BASIC_beats)
frame_rd          struc               ;define the stack
                                    ;structure for passing
                                      ;arguments to BASIC
savebpl           dw       ?          ;caller's base pointer
saveretl          dd       ?          ;return offset and
                                      ;segment pushed by BASIC
BASIC_beats       dw       ?          ;place to return heart
                                      ;beats to BASIC
frame_rd          ends

                  ;subroutine wrbuffer (analog)
frame_wr    struc         ;define the stack structure
                          ;   for passing
                          ;arguments from BASIC to
                          ;   analog buffer
savebp2     dw     ?      ;caller's base pointer
saveret2    dd     ?      ;return offset and segment
                          ;  pushed by BASIC
analog      dw     ?      ;place to receive analog value
                          ;  from BASIC
frame_wr    ends

                          ;subroutine hrsetup(B_lreset,
                          ;   Brfa_scal,Blfa_scal,Bbase_
                          ;   rate)
frame_hr    struc         ;define the stack structure for
                          ;   passing
                          ;arguments from BASIC to heart
                          ;  rate controls
```

```
savebp3     dw    ?    ;caller's base pointer
saveret3    dd    ?    ;return offset and segment pushed
                       ;   by BASIC
Bbase_rate dw     ?    ;BASIC's lowest divider for heart
                       ;  rate
Blfa_scal   dw    ?    ;BASIC's low frequency scaler
                       ;  (amplitude)
Brfa_scal   dw    ?    ;BASIC's high frequency scaler
                       ;  (amplitude)
B_lreset    dw    ?    ;BASIC's low frequency timer
                       ;  reset value
frame_hr    ends

                  ;..........code segment begins here

cseg_calibs       segment 'code'
basic_dgroup     group   data,stack,const,heap,memory
                                  ;defining link to BASIC
porta            equ     0700H   ;port definitions for
                                 ;8255 port expander
portb            equ     0708H   ;these addresses are
                                 ;decoded on the homemade
portc            equ     0710H   ;board
control          equ     0718H   ;control word in the
                                 ;8255
timer0           equ     0720H   ;8253 timer0 register
timer1           equ     0721H   ;8253 timer1 register
timer2           equ     0722H   ;8253 timer2 register
con8253          equ     0723H   ;8253 control register


            ;-------------------------------------------;
            ; timebase interrupt handler (not accessible to;
            ; BASIC)                                      ;
            ;-------------------------------------------;
                  ;this routine reads the A/D every timer0
```

```
                ;tick
                ;with the next point in the analog
                ;buffer

tbase_int       proc    far     ;this procedure is not
                                ;made public
                assume  cs:cseg_sync,ds:dseg_
                   base,es:nothing,ss:nothing
                push    ax      ;save registers used
                                ;during interrupt
                push    bx      ;
                push    dx      ;
                push    ds      ;

                mov     ax,dseg_base    ;set up segment
                                ;register for data area
                mov     ds,ax           ;


                ;..........increment counter used for
                            ;low frequency generation
                dec   tbase_ctr     ;decrement
                                    ;interrupt counter
                jnz   ctr_ok        ;if not zero then
                                    ;continue
                mov   ax,tbase_rst  ;else reload reset
                                    ;value
                mov   tbase_ctr,ax  ;
                ctr_ok:
                        ;..........get analog value from
                        ;buffer and send to DAC

                mov   bx,tbase_ptr    ;get pointer to
```

```
                                  ;analog data
            dec    bx             ;
            mov    al,tbase_buffer[bx]  ;get analog
                                        ;value

            mov    dx,porta       ;send analog value
                                  ;to DAC
            out    dx,al          ;

            mov    dx,control     ;toggle the write
                                  ;latch for the DAC
            mov    al,6           ;by using direct
                                  ;bit reset
            out    dx,al          ;and
            inc    al             ;reset commands
            out    dx,al          ;

            dec    tbase_ptr      ;point to next
                                  ;value
            jnz    tbase_eoi      ;if zero, reset
                                  ;pointer
            mov    ax,tbase_len   ;reset with buffer
                                  ;length
            mov    tbase_ptr,ax   ;

            ;..........acknowledge interrupt to
            ;          8259A
tbase_eoi:  mov    al,20H   ;send EOI to 8259A
            out    20H,al   ;

            pop    ds       ;restore registers which
                            ;were used
            pop    dx       ;
            pop    bx       ;
            pop    ax       ;
            iret            ;return to place where
```

```
                                        ;interrupt occurred

debugmsgl       db      'this is the end of the time
                         base interrupt'

tbase_int       endp


            ;------------------------------------------;
            ; heart beat interrupt handler (not accessible ;
            ; to BASIC)                                ;
            ;------------------------------------------;

            ;this routine updates the timerl rate generator
            ;every heart beat with the divider necessary to
            ;generate the next heart beat
            ;
            ;the respiratory modulation is given by a scaler
            ;   (0-255)
            ;times the present value of the respiratory
            ;   signal.
            ;the low frequency modulation is given by scaler
            ;    (0-255)
            ;times a value selected from the respiratory
            ;    buffer.
            ;the value selected is the
            ;    (tbase_ctr/tbase_rst)*buffer_length
            ;element

hbeat_int       proc    far     ;this procedure is not
                                ;made public
                assume  cs:cseg_calibs,ds:dseg_tbase
                assume  es:nothing,ss:nothing
```

```
        push    ax          ;save registers during
                            ;interrupt
        push    bx          ;
        push    cx          ;
        push    dx          ;
        push    ds          ;

        mov     ax,dseg_tbase     ;set up segment
                             ;register for data area
        mov     ds,ax             ;

        inc     heartbeats        ;increment heart
                                  ;   beat counter

;........calculate low frequency modulation
;        (the tbase buffer is used as a trig
;           table here)
mov     ax,tbase_ctr      ;get number of 1280Hz
                          ;pulses
dec     ax                ;
mul     tbase_len         ;scale by length of
                          ;  respiratory
                          ;  buffer
div     tbase_rst         ;divided by reset
                          ;value to get
                            pointer
mov     bx,ax             ;to low frequency
                          ;  modulation
mov     al,tbase_buffer[bx]   ;get sinusoidal
                          ;        modulation
mul     lfa_scal          ;and scale
                          ;   appropriately
mov      cx,ax            ;cx accumulate
                          ;divider for 1280Hz
                            clock
```

```
;........calculate respiratory modulation
mov     bx,tbase_ptr      ;get present
                          ;respiration signal
mov     al,tbase_buffer[bx]   ;from buffer
mul     rfa_scal          ;scale with rfa scaler
add     cx,ax             ;and add to cx

add     cx,base_rate      ;finally add base rate
                          ;to get
                          ;  value for
                          ;timer1 (heart rate
                          ;generator on
                          ;   8253)

;.......send new divider to 8253 timer
mov     al,76H            ;set timer 1 to square
                          ;  wave
                          ;  generator
mov     dx,con8253        ;
out     dx,al             ;

mov     dx,timer1         ;send divider to
                          ;timel
mov     al,cl             ;low byte first
out     dx,al             ;
mov     al,ch             ;high byte next
out     dx,al             ;

     ;..........acknowledge interrupt to
     ;           8259A
     mov     al,20H  ;send EOI to 8259A
     out     20H,al  ;

     pop     ds      ;restore registers and
     pop     dx      ;
     pop     cx      ;
```

```
                pop     bx        ;
                pop     ax        ;
                iret              ;return to place where
                                  ;interrupt occurred

debugmsg2       db      'this is the end of the heart
                         beat interrupt'

hbeat_int       endp



            ;----------------------------------------------;
            ; subroutine instint (install_interrupts)      ;
            ;----------------------------------------------;

instint         proc    far
                public  instint
               ;public symbol allows external references
               ;es,ds used to access interrupt and must
               ;  be restored movsw
               ;uses (ds:si)(es:di) addr
                assume  cs:cseg_calibs,ss:basic_
                    dgroup,ds:basic_dgroup
                assume  es:int_buffer

                ;..........save registers
                push   ds         ;save ds register on the
                                  ;  stack
                push   es         ;save es register on the
                                  ;  stack

                push    bp        ;save BASIC base pointer
                                  ;    for return to BASIC
                mov     bp,sp     ;point stack pointer at
```

```
                                ;frame reference to
                                ;address of BASIC analog
                                ;data buffer

                push    ax      ;save additional
                                ;registers
                push    si      ;
                push    di      ;

                ;set up the segment registers as assumed

                mov     ax,int_buffer    ;
                ;es points to buffer area to save
                ;DOS dummy interrupt vector
                mov     es,ax            ;
                mov     ax,0             ;ds points to
                                ;abs0 (interrupt table)
                mov     ds,ax            ;
                assume  ds:abs0          ;

                      ;setup access to interrupt vectors
                lea     di,save_int      ;load offset of
                                      ;save_int in es,di
                lea     si,IRQ3_int      ;load offset of
                                      ;IRQ3_int in ds,si
                movsw                    ;save DOS dummy
                                ;interrupt vectors to be
                movsw                    ;restored later
                movsw                    ;now saving IRQ4
                movsw                    ;


;install the DAC timebase (IRQ3)
                mov     IRQ3_int+2,cseg_calibs
                mov     IRQ3_int,offset tbase_int;
                        ;interrupt handler now
```

```
;install the heart beat (IRQ4) interrupt handler now
                mov     IRQ4_int+2,cseg_calibs;
                mov     IRQ4_int,offset hbeat_int;


                ;..........return to BASIC

                pop     di      ;restore additional
                                 registers
                pop     si      ;
                pop     ax      ;

                pop     bp      ;restore BASIC's base
                                ;pointer and
                pop     es      ;segment registers
                                  before returning
                pop     ds      ;
                ret     0       ;delete 0 parameters (0
                                ;bytes) from the stack
                                ;and return to the
                                ;calling routine

debugmsg3       db      'this is the end of the
                        interrupt installation'


instint         endp


                ;------------------------------------;
                ; subroutine exstint (exstall_       ;
                ; interrupts)                        ;
                ;------------------------------------;
```

```
exstint         proc    far
                public  exstint ;public symbol allows
                                   ;external references
                assume  cs:cseg_calibs,ss:basic_dgroup
                assume  ds:int_buffer,es:abs0
                ;es,ds used to access interrupt
                ;vectors and must be restored
                ;movsw uses (ds:si)(es:di) addr

                ;..........save registers

                push    ds      ;save ds register on the
                                ;  stack
                push    es      ;save es register on the
                                ;  stack
                push    bp      ;save BASIC base pointer
                                ;    for return to BASIC
                mov     bp,sp   ;point stack pointer at
                                ;     frame reference to
                                ;access arguments passed
                                ;   by BASIC (none here)

                push    ax      ;save additional
                                ;registers
                push    si      ;
                push    di      ;
                                ;set up the segment
                                ;  registers as assumed
                mov     ax,0            ;es points to
                                ;abs0 (interrupt table)
                mov     es,ax           ;
                mov     ax,int_buffer   ;ds points to
                                ;buffer area to save
                mov     ds,ax           ;DOS dummy
                                ;interrupt vector
```

```
                ;setup access to interrupt vectors
        lea     di,IRQ3_int        ;load offset of
                                 ;IRQ3_int in es,di
        lea     si,save_int        ;load offset of
                                 ;save_int in ds,si
        movsw                      ;restore DOS
                         ;dummy interrupt vectors
        movsw                      ;for IRQ3
        movsw                      ;and IRQ4
        movsw                      ;


        ;..........return to BASIC

        pop     di        ;restore additional
                          ;  registers
        pop     si        ;
        pop     ax        ;

        pop     bp        ;restore BASIC's base
        pop     es        ;pointer and segment
        pop     ds        ;registers before
                          ;returning
        ret     0         ;delete 0 parameters (0
                          ;bytes) from the stack
                          ;and return to the
                          ;calling routine

debugmsg4       db      'this is the end of the
                         interrupt exstallation'

exstint         endp
```

```
;-------------------------------------;
; subroutine rdbeat (read_heart_beats  ;
;-------------------------------------;


rdbeat          proc    far
                public rdbeat    ;public symbol allows
                                 ;external references
                assume cs:cseg_calibs,es:dseg_tbase
                assume ds:basic_dgroup,ss:basic_dgroup


                ;..........save registers

                push    bp       ;save BASIC base pointer
                                 ;for return to BASIC
                mov     bp,sp    ;point stack pointer at
                                 ;frame reference to
                                 ;access arguments passed
                                 ;by BASIC (one here)

                push    ax       ;save additional
                                 ;registers
                push    es       ;
                push    di       ;

                mov     ax,dseg_tbase   ;set up segment
                                  ;register for data area
                mov     es,ax           ;


                mov     ax,heartbeats           ;get
                                 ;beats from local memory
                mov     di,[bp].BASIC_beats     ;
                mov     [di],ax                 ;send
```

```
                                  ;beats to BASIC

                ;.........return to BASIC

                pop     di        ;restore additional
                                   registers
                pop     es        ;
                pop     ax        ;

                pop     bp        ;restore BASIC's base
                                  ;pointer,
                ret     2         ;delete 2 parameters (4
                                  ;bytes) from the stack
                                  ;and return to the
                                  ;calling routine

debugmsg5       db      'this is the end of the heart
                         beat read routine'

rdbeat  endp


                ;---------------------------------------;
                ; subroutine wrbuffer(analog)           ;
                ;---------------------------------------;

wrbuffer        proc    far
                public wrbuffer   ;public symbol allows
                                  ;external references
                assume cs:cseg_calibs,es:dseg_tbase
                assume ds:basic_dgroup,ss:basic_dgroup


                ;.........save registers
```

```
        push    bp          ;save BASIC base pointer
                            ;for return to BASIC
        mov     bp,sp       ;point stack pointer at
                            ;frame reference to
                            ;access arguments passed
                            ;by BASIC (one here)

        push    ax          ;save additional
                            ;registers
        push    bx          ;
        push    es          ;
        push    si          ;
        mov     ax,dseg_tbase    ;set up segment
                             ;register for data area
        mov     es,ax            ;

        mov   si,[bp].analog    ;get analog value
                                ;from BASIC
        mov   ax,[si]           ;
        test  ah,OFFH           ;if upper byte is
                                ;zero
        jz    new_buff          ;then install a
                                ; new point in
                                ;  the buffer
        mov   tbase_len,0       ;otherwise reset
                                ;the buffer
        mov   tbase_ptr,1       ;
        jmp   wr_ret            ;

        mov   bx,tbase_len      ;get present
                                ;pointer and
                                ;use it
        mov   tbase_buffer[bx],al   ;to store
                                ;   buffer value
        inc   tbase_len         ;point to next
                                ;buffer value
```

```
                ;..........return to BASIC

                pop     si      ;restore additional
                                ;registers
wr_ret:         pop     es      ;wr_ret:
                pop     bx      ;
                pop     ax      ;

                pop     bp      ;restore BASIC's base
                                ;pointer,
                ret     2       ;delete 1 parameters (2
                                ;bytes) from the stack
                                ;and return to the
                                ;calling routine

debugmsg6       db      'this is the end of the buffer
                         write routine'

wrbuffer        endp


;--------------------------------------------------------;
; subroutine hrsetup(B_lreset,Brfa_scal,Blfa_scal,       ;
; Bbase_rate)                                            ;
;--------------------------------------------------------;

                proc    far
                public hrsetup  ;public symbol allows
                                  external references
                assume cs:cseg_calibs,es:dseg_tbase
                assume ds:basic_dgroup,ss:basic_dgroup


                ;...........save registers
```

```
push   bp              ;save BASIC base
                       ;pointer for return
                       ;to BASIC
mov    bp,sp           ;point stack pointer
                       ;at frame
                       ;reference to
                       ;access arguments
                       ;passed by BASIC
                       ;(one here)

push   ax              ;save additional
                       ;registers
push   es              ;
push   si              ;

mov    ax,dseg_tbase       ;set up segment
                           ;register for
                       ;data area
mov    es,ax           ;

mov    si,[bp].Bbase_rate   ;get lowest
                       ;divisor for heart
mov   ax,[si]          ;rate from BASIC
mov    base_rate,ax      ;and save in local
                       ;       data
                       ;    segment

mov    si,[bp],Blfa_sacl    ;get low freq
                       ;          modulation
                       ;          scale
mov    ax,[si]         ;         from BASIC
mov    lfa_scal,al ;and save LSbyte in
                       ;local data
                       ;   segment
```

```
        mov   si,[bp].Brfa_scal   ;get high freq
                            ;     modulation scale
        mov   ax,[si]       ;from BASIC
        mov   rfa_scal,al         ;and save
                            ;LSbyte in local data
                            ;segment
        mov   si,[bp].B_lreset    ;get low freq
                            ;   timer reset value
        mov   ax,[si]       ;from BASIC
        mov   tbase_rst,ax        ;and save in
                            ;  local data segment

        ;..........return to BASIC

        pop   si            ;restore additional
                            ;registers
        pop   es        ;
        pop   ax        ;

        pop   bp        ;restore BASIC's base
                        ;pointer,
        ret   8         ;delete 4 parameters (8
                        ;  bytes) from the stack
                        ;and return to the
                        ;  calling routine

debugmsg 7      db    'this is the end of the heart rate
                       setup routine'

hrsetup         endp

cseg_calibs     ends

                end
```

APPENDIX B

1985 - Makoto R. Arai
Laura E. McAlpine, and
Daivd Gordon

```
' SYNCTS19 - program to test synchrounous data
'            acquisition and also
'            test asynchronous processing using
'            board#2
'            addition: asynchronous data
'            archiving (poll driven)
'            reviewing old data
' last revision:  15 May 1985
'
' REQUIRED SUBROUTINES: <MODULE>
'
'       instint(fdbuf1ptr,fdbuf2ptr,fdbuf3ptr)
'         <SYNC7S>
'       exstint                          <SYNC7S>
'       rdbeat(heart,sync)                <SYNC7S>
'       rdbuf(dataptr,bufferno)           <SYNC7S>
'       rdptrs(adrd,hbrd,adflag,hbflag) <SYNC7S>
'
'       swindow(xmins,xmaxs,ymins,ymaxs)
'         <GWINDOW3>
'       dwindow(xmind,xmaxd,ymind,ymaxd)
'         <GWINDOW3>
'       clrwindw                       <GWINDOW3>
'       axes                           <GWINDOW3>
'       scaler(dataptr,gdataptr,numval)
'         <GWINDOW3>
'
'       fgraph(dataptr,numval,xnow,linemask)
'         <FGRAPH8>
'               [for scaled graphs, use
```

```
        '              xnow=xmins,
        '              numval=numvalg=xmaxs-xmins+1,
        '              and gdataptr]
        '       dumpgr   [to dump graphics]      <DUMPGR>
        '


        defint a-y        ' only z denotes a real number
        defdbl z
        dim zreal(514),zrimag(514),zdata(1025)
        dim ydata(1025),ydatag(1025)
        dim hb1(1025),hb2(1025),zhr(1025)
        dim zspec.hb.real(512),zspec.hb.imag(512)
        dim sresetval(5),resprstval(5)
        dim linetype(3),histogram(100)
        def fnzmag(z1,z2)=z1*z1+z2*z2
        def fnzcoher(zr1,zi1,zr2,zi2)=fnzmag
          (zr1*zr2+zi1*zi2,zi1*zr2-zr1*zi2)


        ' initialize timer reset values
1       sval=27 : for i=1 to 5 sresetval(i)=sval :
          sval=sval+sval : next i
2       sval=1381 : for i=0 to 3 : resprstval(i)=sval :
          sval=sval+sval : next i
3       resprstval(4)=sval


        ' define fft parameters
4       fftsize=1024 : npair=fftsize/2 :
          znpair=cdbl(npair) : lpower=9

5      for i=0 to 514 : zreal(i)=0# : zrimag(i)=0# :
         next i

datacycle=0
```

```
          '  flag for automatic fft: when non-zero,
          '   marks stage of data
          '   processing (semi asynchronous)
cyclewait=0
        ' define linetype for plots
        linetype(0)=&HFFFF
        linetype(1)=&HAAAA
        linetype(2)=&HCCCC
        linetype(3)=&HFAFA
        req.cls=0
        sounder=1


        'define ports on 8253
        timer0=&h704
        timer1=&h705
        timer2=&h706
        con8253=&h707


        'define ports on 8255
        porta=&H71C
        portb=&H71D
        portc=&H71E
        con8255=&H71F


        ' set up sampling rate for heart rate timer and
        '   respirations
        gosub 100


        ' first set 8255 ports A,C to output, port B to
        '   input
        ' turn the gates on using the 8255 at bits 0,1,2
```

```
'   on portc
' by setting portc to 1FH
' this also selects channel 0 for the A/D
out con8255,130
out portc,&H1F



' now go through required startup subroutines to
'   set up data archives
    open "R",1,"resp.dat",2048
    open "R",2,"hb1.dat",2048
    open "R",3,"hb2.dat",2048
    open "R",10,"trends.dat",128

31  field #1,2048 as analog$
field #2,2048 as fdhb1$
field #3,2048 as fdhb2$
field #10,128 as trends$

fdflag=0
fdrecord=1
record1no=0 : record2no=0 : record3no=0 :
  record10no=0
adflag1st=0 : hbflag1st=0
fdbuf1ptr=varptr(#1)+188        ' set up
     'pointers to disk buffers
fdbuf2ptr=varptr(#2)+188
fdbuf3ptr=varptr(#3)+188

        '.........field definitions for
        '            trend data file
field #10,8 as hr$,8 as rr$,8 as rcf$,8
  as lfa$,8 as rfa$,8 as coher$
field #10,48 as dummy1$,8 as ratio$,8
  as cratio$,8 as hrintegral$
```

```
field #10,72 as dummy2$,8 as respintegral$,8
  as timestamp$
field #10,120 as dummy3$,2 as hbrecord$,2
  as adrecord$
field #10,124 as dummy4$,2 as hbeat$,2
  as samplrate$


' first print out the present value of the
'   interrupt vectors
locate 23,1 : gosub 20000
gosub 19000


' make sure interrupts are off before installing
'   handlers
mask=inp(&h21) : mask=mask or 24 : out &h21,mask

' install the interrupts
call instint(fdbuf1ptr,fdbuf2ptr,fdbuf3ptr)
locate 24,1 : gosub 20000
gosub 19000


' turn interrupts back on
mask=inp(&h21) : mask=mask and &h0e7 : out
  &h21,mask


40 locate 1,1 : gosub 20000
print "commands: c(ounts), f(ft), g(raph),
   i(in on), q(uit), r(beats)";
print "s(tore), x(cls), #(samples);

' wait until user hits a key
41 savekey$=""
```

```
        while len(savekey$)=0 and datacycle<=0
           savekey$=savekey$+inkey$:gosub 30000:locate
             24,70:print time$;:wend

        while datacycle=1
           fdrecord=record1no : fdflag=1
                            'set up future A/D analysis
           analrec.ad=record1no : analrec.hr=record2no+1
           if req.cls=1 then cls : req.cls=0
              'clear screen if needed

    gosub 950  '......analyze heart rate
42              hrspecsum#=zspectsum*2#

    gosub 900   '.........analyze A/D data (from floppy
43              respspecsum#=zspectsum*2#

           gosub 15000
           '             calculate spectral amplitudes
           gosub 16000
                                        save trend data

           datacycle=cyclewait : wend
        'end auto data analysis cycle


49
        if savekey$="c" then gosub 60
        ' print timer counts
        if savekey$="f" then gosub 900
        ' fft A/D buffer contents
        if savekey$="F" then gosub 950
        ' fft heart rate buffer contents
        if savekey$="g" then gosub 12700
```

```
 ' graph current A/D buffer
 if savekey$="G" then gosub 12710
 ' graph current heart rate buffer
 if savekey$="h" then gosub 90
 ' (no) plot histogram
 if savekey$="p" then gosub 91
 ' (no) print trends
 if savekey$="i" then gosub 80
 ' unmask interrupt 3
 if savekey$="I" then gosub 81
 'unmask interrupt 4
 if savekey$="q" then goto 9996
 ' quit
 if savekey$="r" then gosub 50
 ' print heart beats
 if savekey$="S" then gosub 800
 ' analyze data in disk file (set fdflag)
 if savekey$="t" then gosub 16500
 ' print out the trends
 if savekey$="x" then cls       'clear screen
 if savekey$="#" then gosub 100
 ' reset sampling rate
 if savekey$="?" then gosub 700  'help
 savekey$=""

goto 41


'print present value of heartbeats

50      locate 24,1 : gosub 20000
        call rdbeat(heart,sync)
        print "heart beats: ";heart,"sync pulses:
           ";sync;time$;
        return
```

```
        ' print present value of counters
60      out con8253,0           'latch timer0
        tlow0=inp(timer0)
        thigh0=inp(timer0)
        out con8253,&h40        'latch timer1
        tlow1=inp(timer1)
        thigh1=inp(timer1)
        out con8253,&h80        'latch timer2
        tlow2=inp(timer2)
        thigh2=inp(timer2)
        locate 24,1 : gosub 20000
        print "timer0: ";tlow0+thigh0*256;tab(20);"
           timer1: ";tlow1+thigh1*256;
61      print tab(40);"timer2: ";tlow2+thigh2*256#;
        return


        ' print out interrupt controller parameters:
        ' entry point for IRQ3
80      mask=inp(&h21) : mask=mask xor 8 : out &h21,mask
        goto 82
        ' entry point for IRQ4
81      mask=inp(&h21) : mask=mask xor 16 : out
           &h21,mask
82      mask=inp(&h21)
        locate 24,1 : gosub 20000
        print "8259 IMR(interrupt mask regsiter)=
           ";mask;" =";hex$(mask);
        return


        ' (re)set sampling rates
        ' set timer0 to 16 bit square wave rate
```

```
        ' generator mode
        ' set timers 1,2 to 16 bit rate generator mode
100     out con8253,&h36
        out con8253,&h74
        out con8253,&hB4

                '..........set real time multiplier
105     locate 23,1 : gosub 20000
        input "real time multiplier: ",rt.mult
        rt.multqual=0
        if rt.mult=1 then rt.multqual=1
        if rt.mult=2 then rt.multqual=2
        if rt.mult=4 then rt.multqual=3
        if rt.mult=8 then rt.multqual=4
        if rt.multqual<>0 then goto 110
        beep : goto 105


        ' get heart rate resolution desired to reset
        ' timer0 reset value
110     locate 1,1 : gosub 20000
        input "heart rate resolution: (11,23,45,91,181
           usec) ",hrresol

        ' check heart rate resolution validity
        hrqual=0
        if hrresol=11 then hrqual=1
        if hrresol=23 then hrqual=2
        if hrresol=45 then hrqual=3
        if hrresol=91 then hrqual=4
        if hrresol=181 then hrqual=5
        if hrqual<>0 then sreset=sresetval(hrqual) :
           goto 120
        beep : goto 110
        ' invalid heart rate resolution
```

```
                                  'set timer 0 to 88384Hz
                                  'timebase (11.3 usec res
'      sreset=27                  '(2.38MHz/27)(max resp
                                  'samples then 64Hz)

                                  'set timer 0 to 44192Hz
                                  'timebase (22.6 usec res
'      sreset=54                  '(2.38MHz/54)(max resp
                                  'samples then 32Hz)

                                  'set timer 0 to 22096Hz
                                  'timebase (45.3 usec res
'      sreset=108                 '(2.38MHz/108)(max resp
                                  'samples then 16Hz)

                                  'set timer 0 to 11048Hz
                                  'timebase (90.5 usec res
'      sreset=216                 '(2.38MHz/216)(max resp
                                  'samples then 8Hz)

                                  'set timer 0 to 5524Hz
                                   timebase (181 usec res
'      sreset=432                 ' (2.38MHz/432)(max resp
                                    samples then 4Hz)


                  '..........set respiratory sampling rate
120    locate 2,1 : gosub 20000
       print "respiratory sampling rate: ( 4";
       twopwr=4 : for i=hrqual+rt.multqual to 5 :
       twopwr=twopwr+twopwr
           print using ",##";twopwr; : next i : print "
             Hz) ";
       input respsampl
```

```
' check respiratory sampling rate validity
respqual=0 : respsampl.eff=respsampl*rt.mult
if respsampl=4 then respqual=1
if respsampl=8 then respqual=2
if respsampl=16 then respqual=3
if respsampl=32 then respqual=4
if respsampl=64 then respqual=5
if respqual=0 or respqual+hrqual+rt.multqual>7
   then beep : goto 120

resprst=resprstval(7-hrqual-respqual-
   rt.multqual)

          '..........set cycle delay time between
          '          analyses
130 locate 3,1 : gosub 20000
input "waiting time between cycles: ",dropcycle
if dropcycle<0 or dropcycle>5 then beep : goto
   130
cyclewait=0-dropcycle

out timer0,(sreset mod 256)
' system timebase generated here out
'    timer0,(sreset\256)

out timer1,(resprst mod 256)
' timer 1 counts timebase and outputs out
'   timer1,(resprst\256)
' the respiratory sampling rate

out timer2,0
' set timer 2 as an overflow counter for the
'   out timer2,0
' number of overflows (65536 counts)
```

```
200     timer2over#=65536#
        ' overflow value for timer2
201     zlover=resprst              ' reset count for timerl
202     zlfreq=14318180#/6#/sreset
        ' timerl input clock frequency
203     zhrsampler=zlover/zlfreq
        ' timerl output=sampling interval
204     segment.time=fftsize*zhrsampler
205     zlfreq.real=zlfreq/rt.mult
        ' real time used to calculate HR
206     zhrsampler.real=zlover/zlfreq.real

                  '..........respiratory peak search
                  '                 parameters
210     minrespfrq#=.2#
        ' start at frequency (in pixels)
211     minresp=minrespfrq#/respsampl*1024
212     combwidth#=.032#
        use comb tooth width (in pixels)
213     combpix=combwidth#/respsampl*1024
214     if combpix<=0 then combpix=0

                  '..........low frequency
                            peak/integration parameters
220     pixel.04=cint(40.96#/fftsampl)+1
        ' pixel for .04Hz
221     pixel.10=cint(102.4#/fftsampl)+1
        ' pixel for .10Hz
222     fft.expansion=respsampl/fftsampl

        if datacycle=0 then datacycle=-1
        if recordlno=0 then return
        ' on startup don't delay
        ' exclude the current data segment
        ' from analysis since changes in
        ' sampling rate will introduce glitches
```

```
        return

        ' set floppy disk flag (fdflag) to analyze data
        ' stored on floppy (resp)
800     fdflag=1
        locate 23,1 : gosub 20000 : input "record
           number: ",fdrecord
        if fdrecord>=1 and fdrecord<=recordlno then
           gosub 12700 : return
        locate 24,1 : gosub 20000 : beep : print
           "invalid record number";
        return

        ' set up data for fft here
        ' get analog data from the A/D
900     gosub 12700      ' get analog data and plot
901     for i=1 to fftsize : zdata(i)=ydata(i) : next i
902     locate 23,1 : gosub 20000 : print "A/D buffer is
           transformed";

        xmins=330 : xmaxs=630 : ymins=102 : ymaxs=167
        call swindow(xmins,xmaxs,ymins,ymaxs)

        glabel=3         ' plot label is "resp spect"
        gosub 10000      ' fft
        return

        ' get heart rate data for fft
950     locate 23,1 : gosub 20000 : print "heart rate is
           transformed";
951     gosub 12710      ' get hr function and plot it
```

```
952     for i=1 to fftsize : zdata(i)=zhr(i) : next i

953     xmins=330 : xmaxs=630 : ymins=28 : ymaxs=93
954     call swindow(xmins,xmaxs,ymins,ymaxs)

955     glabel=4         ' plot label is "hr spect"
956     gosub 10000      ' fft

                ' save spectrum in spec.hr buffers
960     for i=0 to 512
961        zspec.hb.real(i)= zreal(i) :
              zspec.hb.imag(i)=zrimag(i)
962        next i

        return




        ' exstall the interrupt and print vector
9996    cls
                ' make sure interrupts are off before
                  removing handlers
        mask=inp(&h21) : mask=mask or 24 : out &h21,mask

                ' remove interrupt handlers
        screen 0

        locate 4,1
        gosub 19000
        call exstint
        locate 5,1
        gosub 19000
        locate 21,1
```

```
        ' close files after storing last bit of data
        bufferno=0
        call rdbuf(fdbuf1ptr,bufferno)
        put #1,record1no+1
        bufferno=1
        call rdbuf(fdbuf2ptr,bufferno)
        put #2,record2no+1
        bufferno=2
        call rdbuf(fdbuf3ptr,bufferno)
        put #3,record3no+1


        close #1,#2,#3,#10

        ' and quit
9999    stop



        ' FFT ROUTINE
        '
        ' set up the data
        '
10000   zreal(0)=0#
10001   zrimag(0)=0#
10002   zreal(npair+1)=0#
10003   zrimag(npair+1)=0#

        ' compute mean value of array
10004   zmean=0#
10005   for i=1 to fftsize : zmean=zmean+zdata(i)
            : next i
10006   zmean=zmean/1024#
```

```
10007   for k=1 to npair : j=k+k-1 : zreal(k)=zdata
          (j)-zmean
10008     zrimag(k)=zdata(j+1)-zmean : next k

10009   ' locate 24,1 : gosub 20000
10010   ' print "arrays initialized at
        ' ";time$;space$(20);

        '
        ' fft routine <fftandift> begins here
        '
10011   ' locate 24,1 : print "entering fft routine at
        ' ";time$;space$(20);
10012   k=0
10013   for j=1 to npair-1 : i=2
10014     ndivi=npair/i
10015     if k<ndivi then 10017
10016         k=k-ndivi : i=i+i : goto 10014
10017     k=k+ndivi
10018     if k<=j then 10025
10019         za=zreal(j+1)
10020         zreal(j+1)=zreal(k+1)
10021         zreal(k+1)=za
10022         za=zrimag(j+1)
10023         zrimag(j+1)=zrimag(k+1)
10024         zrimag(k+1)=za
10025    next j
10026   ' locate 24,1:print "bit reversal completed at
        ' ";time$;space$(20);

10030   g=1  : zp=1#
10031   for i=1 to lpower : gosub 30000
        'check if disk requires service
10032   'locate 24,1:print "entering stage ";g;" at
```

```
        '  time ";time$;space$(20);
10033    if i=1 then zsign=-1# else zsign=1#
10034    zc=1# : ze=0#
10035    zq2=(1#-zp)/2# : if zq2<=0# then zq=0# : else
             zq=sqr(zq2)
10036    zp2=(1#+zp)/2# : if zp2<=0# then zp=0# : else
             zp=zsign*sqr(zp2)
10037    itwog=g+g

10040    for r=1 to g
10041        for j=r to npair step itwog
               k=j+g : if k>npair then print "kjg
                   over>> ";k;j;g
10042          za=zc*zreal(k)+ze*zrimag(k)
10043          zb=ze*zreal(k)-zc*zrimag(k)
10044          zreal(k) =zreal(j) -za
10045          zrimag(k)=zrimag(j)+zb
10046          zreal(j) =zreal(j) +za
10047          zrimag(j)=zrimag(j)-zb
10048        next j
10049        za=ze*zp+zc*zq
10050        zc=zc*zp-ze*zq
10051        ze=za
10052    next r
10053    g=itwog
10054  next i
10055  'locate 24,1:print "entering final stage at
           ";time$;space$(20);
10056  gosub 30000
       ' check if disk requires service

10060  za=4#*atn(1#)/znpair
10061  zp=cos(za)
10062  zq=sin(za)
10063  za=zreal(1)
10064  zreal(1)=za+zrimag(1)
```

```
10065   zrimag(1)=za-zrimag(1)
10066   zreal(1)=zreal(1)/2#
10067   zrimag(1)=zrimag(1)/2#
10068   zc=1# : ze=0#

10070   j=2
10071   while j<npair/2
10072     za=ze*zp+zc*zq
10073     zc=zc*zp-ze*zq
10074     ze=za
10075     k=npair-j+2
10076     za=zreal(j)+zreal(k)
10077     zb=(zrimag(j)+zrimag(k))*zc-(zreal(j)-
              zreal(k))*ze
10078     zu=zrimag(j)-zrimag(k)
10079     zv=(zrimag(j)+zrimag(k))*ze+(zreal(j)-
              zreal(k))*zc
10080     zreal(j)=(za+zb)/2#
10081     zrimag(j)=(zu-zv)/2#
10082     zreal(k)=(za-zb)/2#
10083     zrimag(k)=-(zu+zv)/2#
10084   j=j+1 : wend
10085   zrimag(npair/2+1)=-zrimag(npair/2+1)

10090   for j=2 to npair
10091     zreal(j)=zreal(j)/znpair/2#
10092     zrimag(j)=zrimag(j)/znpair/2#
10093   next j
10094   zreal(1)=zreal(1)/znpair
10095   zrimag(1)=zrimag(1)/znpair

        '
        ' fft routine now completed
        '
10100   locate 24,1:print "fft completed
            ";time$;space$(20);
```

```
        '...integrate spectrum
        '     sum up the spectrum noting that only the
        '      first npair elements of
        '     the fft are valid
        '     (npair+1 to fftsize are complex conjugates
        '      of 1 to npair and are
        '        not calculated)
10101   zspectsum=0#
10102   zsummax=0#
10103   ipeak=-1
10104   for i=1 to npair
10105     zadd=fnzmag(zreal(i),zrimag(i))
10106     zspectsum=zspectsum+zadd
10107     if zadd<=zsummax then 10110
10108         zsummax=zadd
10109         ipeak=i
10110   next i

        '
        ' graphing routine for fft spectra
        '
10111   'locate 1,1 : gosub 20000
10113   'print "total spectral weight
        '   <variance>:";zspectsum*2#;
10114   'locate 2,1 : gosub 20000
10115   'print "peak weight : ";zsummax;" peak
        '    frequency= ";
10116   'print (ipeak-1#)/fftsize*respsampl;

10117   gosub 12730
        ' fgraph of spectrum
10118   return
```

```
'-------------------------------'
' UTILITIY ROUTINES HERE        '
'-------------------------------'

' graphing routine: gets data from A/D buffer
'  and displays graph
12700   glabel=1
        numpts=fftsize
        indata=0
        ' local flag
        '   indicating data is read while indata=0 and
        '    fdflag=0
           dataptr=varptr(ydata(1))
           bufferno=0            'read A/D buffer
           call rdbuf(dataptr,bufferno)
           indata=1
           wend

        while indata=0 and fdflag=1
           gosub 30000
        ' check file buffer to see if service is
        '   required
           get #1,fdrecord
           for i=1 to 1024 :
           ydata(i)=cvi(mid$(analog$,i+i-1,2)) : next i
           indata=1
           wend


        xmins=10 : xmaxs=310 : ymins=102 : ymaxs=167
        call swindow(xmins,xmaxs,ymins,ymaxs)

        xmind=0 : xmaxd=300 : ymind=0 : ymaxd=255
        call dwindow(xmind,xmaxd,ymind,ymaxd)
```

```
          ' max A/D value is 255
          call clrwindw
          call axes
          goto 12770


          ' entry point for plot of heart rate function
12710     screen 2            ' get heart rate function
12711     glabel=2
12712     numpts=fftsize
12713     gosub 13000
12714     ibeg=adrd+2
12715     for i=1 to fftsize : if ibeg=i then
              ibeg=ibeg+fftsize
12716       ydata(i)=cint(zhr(ibeg-i)) : next i

          xmins=10 : xmaxs=310 : ymins=28 : ymaxs=93
          call swindow(xmins,xmaxs,ymins,ymaxs)

          xmind=0 : xmaxd=300 : ymind=0 : ymaxd=250
          call dwindow(xmind,xmaxd,ymind,ymaxd)
          ' max hr is 250 bpm

          goto 12770


          ' entry point for plotting spectra (screen
          '   windows already setup)
12730     zgain=250#/zsummax
12731     for i=1 to npair
12732       ydata(i)=cint(zgain*fnzmag
              (zreal(i),zrimag(i))) +1
12733     next i
12734     numpts=npair

                    ' max spectral element (scaled to 250)
```

```
        xmind=0 : xmaxd=300 : ymind=0 : ymaxd=255
        call dwindow(xmind,xmaxd,ymind,ymaxd)

12770   call clrwindw
        call axes

12780   dataptr=varptr(ydata(1))
        gdataptr=varptr(ydatag(1))
        call scaler(dataptr,gdataptr,numpts)
        'correctly selects screen width

        ' entry point for plot of ydatag(i)
12790   x=xmins
        numvalg=xmaxs-xmins+1
        linemask=&hffff
        gdataptr=varptr(ydatag(1))
        call fgraph(gdataptr,numvalg,x,linemask)

        ' graph labels printed here
        on glabel goto 12800,12810,12820,12830
        return  'invalid label

        ' respirations in time domain
12800   if fdflag=1 then locate 14,30 : print
            "rec#";fdrecord : fdflag=0
        return

        ' heart rate in time domain
12810   locate 5,3
        print using "HR= ### bpm";cint(zavghr)
        return

        ' respiratory spectrum
12820   locate 14,63 :       print " Resp Spect ";
        locate 15,63 : print using " (0-
            ##Hz)";respsampl\2
```

```
        gosub 14000
        ' respiratory rate from spectrum by comb method
        locate 14,3
        ' print respiratory rate with time tracing
        print using "RR=### bpm
          (rcf=#.###)";cint(respfreq#*60),respcombfrac#
        return

        ' heart rate spectrum
12830   locate 4,63 :       print " HR Spect ";
        locate 5,63 : print using " (0-##Hz)";fftsampl\2
        return



        'heart rate functions:
        '   read times from memory
        '    convert to heart rate function
        '    FFT resulting buffer
        '    display the spectral amplitudes

13000   call rdptrs(adrd,hbrd,adflag,hbflag)
13002   if record2no=0 then startup=1 else startup=0 '
            startup is special

13003   hbptr1=varptr(hb1(1))
13004   bufferno=1
        'read heart beat buffer 1 (least sig. cts
13005   call rdbuf(hbptr1,bufferno)
13006   locate 24,1 : gosub 20000
13007   print "hbrd= ";hbrd; : anal.beat=hbrd

13008   hbptr2=varptr(hb2(1))
13009   bufferno=2
        'read heart beat buffer 2 (most sig. cts
13010   call rdbuf(hbptr2,bufferno)
```

```
13011   for i=0 to 100 : histogram(i)=0 : next i
        'initialize histogram for deglitching (.4-40Hz)
13012   histomax#=zlfreq.real*2.5#
13013   histoscal#=zlfreq.real/40#

        ' compute time differences for entire hb array
        ' and save in zdata
        ' from the top down
        ' zdata will contain the latest hr intervals,
        ' with the latest in
        ' (hbrd) and older intervals for decreasing
        ' array index
        ' since the timers are decrementing,
        ' lstbeat<thisbeat
        ' (lstbeat is later, therefore smaller)
        ' this relation fails whenever there is a carry
        ' over (timer overflow)
        ' note: timerl overflows exactly fftsize times
        ' during one data segment
13020   lstbeat#=hbl(hbrd) : lstover#=hb2(hbrd)
13022   hbnow=hbrd-1
13023   if hbnow<=0 then hbnow=fftsize
13024   if startup=1 and hbnow=fftsize then return ' no
           data yet

13025   numint=1
                ' valid intervals only (1 less than
                ' buffer size
13026   while numint<fftsize
13027       thisbeat#=hbl(hbnow)
                ' check for overflow of overflow counter
13028       thisover#=hb2(hbnow)
13029       if hb2(hbnow)<cint(lstover#) then
               lstover#=lstover#-timer2over#
13030       hbnow=hbnow-1
```

```
13031       if hbnow=0 then hbnow=fftsize
13032       if hbnow=fftsize and startup=1 then goto
              13048
13033       zdatnow=thisbeat#-lstbeat#+overdif#*zlover
13034           if zdatnow>=0 then goto 13047 '?error

13040        if zdatnow>histomax# then goto 13044
13041        index=cint(zdatnow/histoscal#)
13042        histogram(index=histogram(index)+1
13043        goto 13045
             'keep histogram of intervals (.2-20Hz:
             '   give 10% resolution @2Hz) extended
             '     data lapses
13044           histogram(100)=histogram(100)+1
                ' extended data lapses

13045       zdata(numint)=zdatnow : numint=numint+1
13046       lstbeat#=thisbeat# : lstover#=thisover#
13047       wend
13048   numint=numint-1

                '..........find the interval
                '       corresponding to mean heart rate
                '               1) find largest peak in
                '                 .5-4Hz (2 pixels wide)
                '               2) calculate corrected
                '                  mean interval
                '               3) calculate corrected
                '                  interval variance
                '               4) set slewing
                '                  parameters for HR
                '                  generation

13050   lstint=histogram(4) : hpeak=0 : hpeak.ht=0
13051   for i=3 to 40 : thisint=histogram(i)
13052       if (thisint+lstint)>hpeak.ht then
```

```
                hpeak.ht=thisint+lstint : hpeak=i
13053        lstint=thisint : next i
13054    approx.avg#=(hpeak-0.5#)*histoscal#

13060    zhistsum=0# : zhistsum2=0#
13061    for i=1 to numint :
             index=cint(zdata(i)/approx.avg#)
13062        if index<=0 then index=1
13063        zhistsum=zhistsum+zdata(i)/index : next i
13064    avgint#=zhistsum/numint

13070    for i=1 to numint : index=cint(zdata(i)/avgint#)
13071        if index<=0 then index=1
13072        zdif=zdata(i)/index-avgint# :
                zhistsum2=zhistsum2+zdif*zdif
13073        next i
13074    histvar#=zhistsum2/numint

                ' calculate deglitching parameters
13081    varslew#=31.4#*sqr(histvar#)/respsampl
         '5x max slew (1Hz rfa) slew at least .05Hz
         '   (3bpm)/beat infslew has infimum of slew
         '       maxima
13082    min.maxslew#=.05
13083    infslew#=1#/(1#/avgint#-
           min.maxslew#/zlfreq.real)-avgint#
13084    if maxslew#<infslew# then maxslew#=infslew#
13085    supslew#=avgint#/5#
         'never slew more than 20% HR
13086    if maxslew#>supslew# then maxslew#=supslew#
13087    locate 1,1 : gosub 20000 ': print "maxslew:
           ";maxslew#

         ' compute heart rate waveform next
13100    ztime=0#
         ' time for present heart rate signal
```

```
' pointer in zdata to present beat number
' of beats accepted
13101 intnow=1
13102 beatno=1 :
13103 while zdata(intnow)<=0
13104     intnow=intnow+1 : if intnow>numint then goto
              13140 : wend
13105 zintlst=avgint# : zdropper=avgint# :
          zintnow=zdata(intnow)
13106 znext=zintnow/zlfreq.real
' time of previous heart beat deglitch first
'     beat present heart rate keep statistics for
'      deglitching sampling rate determined by
'         timers
13107 avgnow#=avgint# : gosub 13500
13108 zhrnow=60#*zlfreq.real/zintnow
13109 zsum=zhrnow
13110 zsum2=zhrnow*zhrnow
13111 zincr=zhrsampler.real
13120 numsig=1
' point to heart rate function

13121 while numsig<=fftsize and ztime<=znext
13122     zhr(numsig)=zhrnow : numsig=numsig+1 :
          ztime=ztime+zincr
13123     wend:zintlst=zintnow
13124 if numsig=fftsize+1 then goto 13142
13125     intnow=intnow+1 : if intnow>numint then goto
          13140
13126     zintnow=zdata(intnow) : if zintnow<=0 then
              goto 13125
13127     znext=znext+zintnow/zlfreq.real : gosub
             13500       ' deglitcher
13128     zhrnow=60#*zlfreq.real/zintnow
13129     zsum=zsum+zhrnow : zsum2=zsum2+zhrnow*zhrnow
              : beatno=beatno+1
```

```
13130      goto 13121

13140   zavghr=zsum/beatno
        ' averaged over number of beats
13141   while numsig<=fftsize : zhr(numsig)=zavghr :
            numsig=numsig+1 : wend
13142   zavghr=zsum/beatno

13400   locate 24,13 : print "  avg hr(bpm): ";zavghr;

        ' zhr now has heart rate function
13401   print " ...heart rate function computed";

        return

        ' deglitching of three types employed here:
        '       correction of premature triggers (not
        '       yet)
        '       correction of dropped beats (not yet)
        '       slew rate limiting of final output (a
        '       crude bandlimiter)
13500   if abs(zintnow-zintlst)<maxslew# then return
        'check for dropped beats
13501   numdrop=cint(zintnow/avgnow#) : if numdrop<=0
           then goto 13510
13502   if abs(zintlst-zintnow/numdrop)>maxslew# then
           1350#
13503   zintnow=zintnow/numdrop : sound 1200,sounder :
            return                          'dropped beat
13504   if numdrop>1 then goto 13520 else goto 13510

                ' check for premature trigger (note:
                '       premature trigger assump-
                '       -tion remains in effect
                '       only for glitched time
                '       (if added portion is an
```

```
                    '       acceptable beat,
                    '       (that's how it's used;
                    '       otherwise slew rate
                    '       (limiter extends

                    '             assumption to added portion
13510               if abs(zintnow+zdata(intnow+1)_
                       zintlst)>maxslew# then 13520
13511               zintnow=zintnow+zdata(intnow+1)
                    ' assume premature trigger here
13512               sound 1400,sounder : return

                    ' slew rate limiter
13520       sound 600,sounder : zintnow=zintlstr

            return


            ' calculating the respiratory rate using the
            '    comb method
            ' [spectrum in ydata(*)]
            '       start at frequency :    minrespfrq#
            '       (in pixels):            minresp
            '       use comb tooth width:   combwidth#
            '       (in pixels):            combpix


14000       maxcomb#=0# : respcomb=0 : combstep=combpix\2+1
            ' for loop shifts comb beginning to different
            ' frequencies
14001       for comb=minresp to npair step combstep
14002          curcomb#=0# : harmbeg=comb-combstep+2
14003          lastbeg=harmbeg+9*comb : if lastbeg>npair
                   then lastbeg=npair

                    ' while loop adds up 10 teeth
```

```
               ' (harmonics) in the comb
14004     while harmbeg<=lastbeg
               toothptr=harmbeg
               lstooth=harmbeg+combpix : if
                   lstooth>npair then lstooth=npair

               ' this while loop adds one tooth's
               ' contribution to comb
14007          while toothptr<=lstooth
14008              curcomb#=curcomb#+ydata(toothptr)
14009              toothptr=toothptr+1
14010              wend
14011          harmbeg=harmbeg+comb
14012          wend
14013     if curcomb#>maxcomb# then maxcomb#=curcomb# :
              respcomb=comb
14014     next comb

14050  locate 3,1 : gosub 20000 : print "respiratory
          comb fraction: ";
14051  curcomb#=0# : for i=1 to npair :
          curcomb#=curcomb#+ydata(i) : next i
14052  respcombfrac#=maxcomb#/curcomb# : print using
          "#.###";respcombfrac#;

       ' respcomb now has respiratory frequency or a
       ' subharmonic
       ' to decide which is the first harmonic look at
       ' weight in each tooth
       ' of the comb; a higher harmonic comb must
       ' contribute at least double
       ' amplitude to be designated as the fundamental
       ' (4xspectral weight)

14100  maxtooth#=0 : resptooth=0 : harmbeg=respcomb+1-
          combpix
```

```
14101   lastbeg=harmbeg+9*respcomb : if lastbeg>npair
            then lastbeg=npair

14102      while harmbeg<=lastbeg
14103           toothptr=harmbeg : curtooth#=0#
14104           lstooth=harmbeg+combpix+combpix
14105           if lstooth>npair then lstooth=npair

                        ' add up one widened tooth
14110           while toothptr<=lstooth
14111               curtooth#=curtooth#+ydata(toothptr)
                        : toothptr=toothptr+1
14112               wend
                        ' compare to previous teeth
14120           if curtooth#<4*maxtooth# then goto 14130
14121              maxtooth#=curtooth# :
                       resptooth=harmbeg

14130           harmbeg=harmbeg+respcomb
14131           wend

                ' compute respiratory frequency as peak
                ' average
14200   toothptr=resptooth : respfreq#=0#
14201   lstooth=toothptr+combpix+combpix
14202   if lstooth>npair then lstooth=npair

                ' average frequency over fundamental
                ' peak
14210   while toothptr<=lstooth
14211       respfreq#=respfreq#+ydata(toothptr)
               *cdbl(toothptr-1)
14212       toothptr=toothptr+1
14213       wend
14214   respfreq#=respfreq#/maxtooth#/1024#*respsampl
```

```
14220   resp.lopixel=cint((respfreq#-
          .06#)/respsampl*1024#)+1
        ' integration limits
14221   resp.hipixel=cint((respfreq#+.06#)
          /respsampl*1024#)+1

        return


        ' spectral amplitude calculations
15000   lfa#=0# : rfa#=0# : coherence#=0#
15001   for i=pixel.04 to pixel.10
15002      lfa#=lfa#+fnzmag(zspec.hb.real(i),
               zspec.hb.imag(i))
15003      next i
15004   lfa#=lfa#+lfa#

15010   for i=resp.lopixel to resp.hipixel
15011      rfa#=rfa#+fnzmag(zspec.hb.real(i),
               zspec.hb.imag(i))
15012      next i
15013   rfa#=rfa#+rfa#

15020   for i=1 to 512
15021      coherence#=coherence#+fnzcoher
           (zreal(i),zrimag(i),_
                        zspec.hb.real(i),
                        zspec.hb.imag(i))
15022      next i
15023   coherence#=coherence#/zspectsum

15030   ratio#=lfa#/rfa#
15031   cratio#=lfa#/coherence#

15040   locate 6,60 : print using  "lfa: ##.###";lfa#;
```

```
15041   locate 7,60 : print using  "rfa: ##.###
                               (##.###)";rfa#,coherence#;
15042   locate 8,58 : print using "ratio: ##.###
                               (##.###)";ratio#,cratio#;
        return


        ' storing trend data on floppy disk (file #10)
16000   lset hr$=mkd$(zavghr)
16001   lset rr$=mkd$(respfreq#)
16002   lset rcf$=mkd$(respcombfrac#)
16003   lset lfa$=mkd$(lfa#)
16004   lset rfa$=mkd$(rfa#)
16005   lset coher$=mkd$(coherence#)
16006   lset ratio$=mkd$(ratio#)
16007   lset cratio$=mkd$(cratio#)
16008   lset hrintegral$=mkd$(hrspecsum#)
16009   lset respintegral$=mkd$(respspecsum#)
16010   lset timestamp$=time$
16011   lset hbrecord$=mki$(analrec.hr)
16012   lset adrecord$=mki$(analrec.ad)
16013   lset hbeat$=mki$(anal.beat)
16014   lset samplrate$=mki$(respsampl)

        record10no=record10no+1 : put #10,record10no

        return


        ' reading trend data from floppy disk (file #10)
16500   if record10no<=1 then return
16501   cls

16510   xmins=10 : xmaxs=310 : ymins=2: ymaxs=197 :
```

```
              numvalg=xmaxs-xmins+1
16511   call swindow(xmins,xmaxs,ymins,ymaxs)

16512   call clrwindw
16513   call axes

16520   numpts=record10no
16521   lfa.beg=record10no
16522   rfa.beg=2*record10no
16523   ratio.beg=3*record10no
16524   lastydata=4*record10no
16525   ln10#=log(10#)
16526   xscale#=numvalg/record10no

        ' get trend information from the disk file
16530   for temprec=1 to record10no
16531      get #10,temprec
16532      ydata(temprec)=197-.78#*cvd(hr$)
16533      ydata(temprec+lfa.beg)=197-19.5*cvd(lfa$)
16534      ydata(temprec+rfa.beg)=197-19.5*cvd(rfa$)
16535      ydata(temprec+ratio.beg)=100-
              log(cvd(ratio$))/ln10#*45#
16536      next temprec

16537   for i=1 to lastydata : if ydata(i)<ymins then
           ydata(i)=ymins
16538       if ydata(i)>ymaxs then ydata(i)=ymaxs :
               next i

        ' plot trends here
16540   for trend=0 to 3 : trendoff=trend*record10no
16542      gctr=1 : ydatalst=ydata(1) :
              ydatag(1)=ydatalst
16543      for temprec=2 to record10no :
              gctrmax=temprec*xscale#
16544          gdif=gctrmax-gctr : if gdif<=0 then goto
```

```
                    16550
16545       ydatadif=ydata(temprec+trendoff)-
                    ydatalst : part=0
16546       while gctr<gctrmax : gctr=gctr+1 :
                    part=part+1
16547         ydatag(gctr)=ydatalst+
                      (part/gdif)*ydatadif : wend
16548       ydatalst=ydata(temprec+trendoff)
16550       next temprec
16551     linemask=linetype(trend) : x=xmins
16552     gdataptr=varptr(ydatag(1)) : numvalg=xmaxs-
              xmins+1
16553     call fgraph(gdataptr,numvalg,x,linemask)
16554     next trend

16560   locate 2,42 : print "HR (0-250 bpm)";
16561   locate 3,42 : print "lfa (0-10 bpm^2)";
16562   locate 4,42 : print "rfa (0-10 bpm^2)";
16563   locate 5,42 : print "ratio (.01-100)";

16600   req.cls=1

        return



        ' subroutine to print out the interrupt vectors

19000   def seg=0
        print "IRQ3 @0B*4H: ";hex$(peek(&h2C));
        '  "";hex$(peek(&h2D));" ";
        print hex$(peek(&h2E));
        '  "";hex$(peek(&h2F));tab(40);
        print "IRQ4 @0C*4H: ";hex$(peek(&h30));
        '  "";hex$(peek(&h31));" ";
```

```
        print hex$(peek(&h32));" ";hex$(peek(&h33));
        return

        ' routine to clear the present line
20000   csnow=csrlin:locate csnow,1:print
        return

        ' check pointers to see if any disk files need
        ' to be written
30000   call rdptrs(adwr,hbwr,adflag,hbflag)
30001   if adflag=adflaglst and hbflag=hbflaglst then
                 return

30010   while adflag>record1no+1 : beep : locate 23,1 :
            print "data #1 loss";
30011           record1no=adflag-1 : wend
30020   while hbflag>record2no+1 : beep : locate 23,1 :
            print "data #2 loss";
30021           record2no=hbflag-1 : wend
30030   while hbflag>record3no+1 : beep : locate 23,1 :
            print "data #3 loss";
30031           record3no=hbflag-1 : wend

30040   if adflag<record1no+1 then goto 30050
30041      record1no=adflag : put #1,adflag
30042      if datacycle<=0 then datacycle=datacycle+1
           'if not processing, begin
30050   if hbflag=record2no+1 then record2no=hbflag :
            put #2,hbflag
30060   if hbflag=record3no+1 then record3no=hbflag :
            put #3,hbflag

        locate 3,1 : gosub 20000 : print "current file
        records: ";adflag; print " (#1) ";hbflag;"
```

```
(#2)";
adflaglst=adflag : hbflaglst=hbflag

return

end
```

```
                page    66,80
; sync7s.asm - an assembler routine to handle interrupts
;              from IRQ4 and collect
;              synchronous data from the A/D (board 2
;              configuration assumed)
;              The routine checks A/D readings for
;              output validity
;              Data is loaded by interrupts into both a
;              processing buffer and
;              a disk file I/O buffer to allow quick
;              archival; an overflow
;              flag signals when a disk file buffer
;              should be stored and
;              also indicates whether the disk buffer
;              was corrupted.
;              To acknowledge storage of a disk buffer
;              one must reset the
;              overflow flag using <ackfdio>
; Last revision:  3 May 1985
;
;
                ;-------------------------------;
                ;  8088 interrupt location      ;
                ;-------------------------------;

abs0            segment at 0    ;absolute memory segment
                                ;allows placement of
                                ;interrupt address
                org     0BH*4   ;future heart beat
                          interrupt handler resides
IRQ3_int        dw      2 dup(?);at int 0B

                org     0CH*4   ;8253 timebase interrupt
                                ;handler resides
IRQ4_int        dw      2 dup(?);at int 0C
```

```
abs0            ends            ;

                ;-------------------------------;
                ; int_buffer: area to save DOS  ;
                ;      dummy interrupt ptrs     ;
                ;-------------------------------;

int_buffer      segment         ;data segment containing
                                ;user interrupt buffer

save_int        dw      4 dup(?);offset for two DOS
                                ;interrupts saved
                                ;to be restored using
                                ;exstint

int_buffer      ends            ;

                ;-------------------------;
                ; working storage for     ;
                ; interrupts              ;
                ;-------------------------;

dseg_sync       segment         ;data segment for
                                ;interrupts

                ;..........declare all variables public
                ;          for use by other
                ;          assembly level routines
                public ad_buffer,ad_rd,ad_wr,sync_ctr
                public hb_buffer1,hb_buffer2,hb_rd,hb_
```

```
                        wr,heartbeats

                        ;..........timebase local storage and
                                   buffer

ad_buffer       db      1024 dup(?) ;buffer for A/D
                            values
ad_rd           dw      ?       ;read indicator for A/D
                                ;disk buffer
ad_wr           dw      ?       ;write pointer for A/D
                                ;buffer (incrementing)
sync_ctr        dw      ?       ;counter for timebase
                                ;interrupt (overflows)


                        ;..........heart beat local storage and
                        ;              buffer
                        ;          note:for main clock
                        ;               14.318 180 MHz (osc)
                        ;          system clock
                        ;               4.772 727 MHz (clock)
                        ;          8253 clock
                        ;               2.386 363 MHz (ck8253)
                        ;                  (ck8253 /    432)
                        ;               5.524 KHz      (hb.clk)
                        ;          (ck8253 /596592)  4 Hz
                        ;                                (respck)
                        ;          hb.clk = 1381*respck
                        ;          sync.ctr overflow =
                        ;               16384 sec (4:33:04)

hb_buffer1      dw      1024 dup(?) ;heart beat time
                            stamps for previous 1024
hb_buffer2      dw      1024 dup(?) ;beats (2 words:
                            hb.clk,sync.ctr)
```

```
hb_rd           dw      ?       ;read indicator for
                              ;heart beat disk buffers
hb_wr           dw      ?       ;write pointer
                        ;(incrementing) for hb_buffer

heartbeats      dw      ?       ;keep track of number of
                                ;beats processed

                ;.........pointers to disk file buffers

fd1ptr          label   dword   ;pointer to floppy disk
                                 file #1 buffer
fd1ptroff       dw      ?       ; (offset)
fd1ptrseg       dw      ?       ; (segment)

fd2ptr          label   dword   ;pointer to floppy disk
                                 file #2 buffer
fd2ptroff       dw      ?       ; (offset)
fd2ptrseg       dw      ?       ; (segment)

fd3ptr          label   dword   ;pointer to floppy disk
                                 file #3 buffer
fd3ptroff       dw      ?       ; (offset)
fd3ptrseg       dw      ?       ; (segment)


dseg_sync       ends            ;



                ;-------------------------------------;
                ; setup structures to allow access to;
                ; arguments pased by BASIC           ;
                ;-------------------------------------;

                ; subroutine
```

```
                ; instint(fillptr,fil2ptr,fil3ptr)
frame_rd        struc               ;define the stack
                                 ;structure for passing
                                    ;arguments to BASIC
savebp0         dw      ?           ;caller's base pointer
saveret0        dd      ?           ;return offset and
                                  ;segment pushed by BASIC
B_fil3ptr       dw      ?           ;offset of file #3 disk
                                    ;buffer
B_fil2ptr       dw      ?           ;offset of file #2 disk
                                    ;buffer
B_fillptr       dw      ?           ;offset of file #1 disk
                                     buffer
frame_rd        ends

                ; subroutine rdbeat(BASIC_beats,BASIC_
                ; syncs)
frame_rd        struc               ;define the stack
                                  ;structure for passing
                                    ;arguments to BASIC
savebpl         dw      ?           ;caller's base pointer
saveretl        dd      ?           ;return offset and
                                    ;segment pushed by BASIC
BASIC_syncs     dw      ?           ;place to return sync
                                    ;pulses to BASIC
BASIC_beats     dw      ?           ;place to return heart
                                    ;beats to BASIC
frame_rd        ends

                ; subroutine rdbuf (BASIC_ptr,whichbuff)
frame_rdbuf     struc               ;define the stack
                                    ;structure for passing
                                    ;arguments to BASIC
savebp2         dw      ?           ;caller's base pointer
saveret2        dd      ?           ;return offset and
                                    ;segment pushed by BASIC
```

```
whichbuff        dw      ?        ;place to select which
                                  ;buffer to read
BASIC_ptr        dw      ?        ;place to get pointer to
                                  ;BASIC data array
frame_rdbuf      ends

                 ; subroutine rdptrs
                  ;(adwr,hbwr,adflag,hbflag)
frame_rdptrs     struc            ;define the stack
                                  ;structure for passing
                                  ;arguments to BASIC
savebp3          dw      ?        ;caller's base pointer
saveret3         dd      ?        ;return offset and
                                  ;segment pushed by BASIC
hbflag           dw      ?        ;flag indicating disk
                                  ;file #1,#2 buffers full
adflag           dw      ?        ;flag indicating disk
                                  ;file #1 buffer is full
BASIC_hbwr       dw      ?        ;write pointer for heart
                                  ;beat buffer
BASIC_adwr       dw      ?        ;write pointer for ad
                                  ;buffer
frame_rdptrs     ends



                 ;..........code segment begins here

cseg_sync        segment 'code'
basic_dgroup     group   data,stack,const,heap,memory
                                   ;defining link to BASIC
porta            equ     071CH    ;port definitions for
                                  ;8255 port expander
portb            equ     071DH    ;these addresses are
                                  ;decoded on the homemade
portc            equ     071EH    ;board
```

```
control         equ     071FH   ;control word in the
                                ;8255
timer0          equ     0704H   ;8253 timer0 register
timer1          equ     0705H   ;8253 timer1 register
timer2          equ     0706H   ;8253 timer2 register
con8253         equ     0707H   ;8253 control register


        ;-----------------------------------------------;
        ; timebase interrupt handler (not accessible to;
        ; BASIC)                                        ;
        ;-----------------------------------------------;
                ;this routine reads the A/D every timer1
                ;tick
                ;and stores the point in the analog
                ;buffer


tbase_int       proc    far     ;this procedure is not
                                ;made public
                assume  cs:cseg_sync,ds:dseg_
                sync,es:nothing,ss:nothing
                push    ax      ;save registers used
                                ;during interrupt
                push    bx      ;
                push    cx      ;
                push    dx      ;
                push    si      ;
                push    di      ;
                push    ds      ;
                push    es      ;

                mov     ax,dseg_sync    ;set up segment
                                 ;register for data area
                mov     ds,ax           ;
```

```
                  ;..........increment counters/ decrement
                  ;          pointers
                  inc     sync_ctr        ;increment
                                         ;interrupt counter
                  mov     cx,20           ;allow up to 20
                                           ;rereads of A/D

                  ;..........get analog value from A/D and
                  ;          send to buffer
                  mov     dx,portb        ;get analog
                                         ;value from A/D
                  in      al,dx           ;

                  mov     bx,ad_wr        ;and put analog
                                        ;data pointer in bx
        retry:    mov     ad_buffer[bx],al
                  ;save analog value in ad_buffer

        chk_adc:  in      al,dx           ;reread adc and
                                         ;check if previous
                  cmp     ad_buffer[bx],al   ;value agrees
                  je      adc_ok          ;if value is the
                                          ;same we're done
                  loop    retry           ;retry if retry
                                   ;counter is not depleted
                                          ;failure returns
                                          ;last value read


        adc_ok:   inc     ad_wr           ;increment write
                                          ;pointer
                  cmp     ad_wr,1023      ;see if write
                                           pointer<=1023
                  jle     tbase_eoi       ;if pointer is
                                   ;in range then finish
        int
```

```
;..........reset local ptr and load disk
;          buffer for file #1

        xor     ah,ah           ;zero ah as
                   ;upper byte of A/D reading
        mov     cx,1024         ;load counter
                         ;for 1024 repetitions
        lea     si,ad_buffer    ;load local
                              ;buffer address
        les     di,fdlptr       ;load pointer to
                           ;disk file #1 buffer
fdllp:  lodsb                   ;repeat moves
                   ;1024 times (ds:si->es:di)
        stosw                   ;converting
                                ;bytes to words
        loop    fdllp           ;
        mov     ad_wr,cx        ;reset write
                       ;pointer (wrap around)
        inc     ad_rd           ;increment read
                              ;request for disk

;..........acknowledge interrupt to
;          8259A
tbase_eoi:  mov     al,20H  ;send EOI to 8259A
        out     20H,al  ;

        pop     es      ;restore registers which
                        ;were used
        pop     ds      ;
        pop     di      ;
        pop     si      ;
        pop     dx      ;
        pop     cx      ;
        pop     bx      ;
        pop     ax      ;
```

```
                iret            ;return to place where
                                ;interrupt occurred

debugmsgl       db      'this is the end of the time
                         base interrupt'

tbase_int       endp


        ;-----------------------------------------------;
        ; heart beat interrupt handler (not accessible ;
        ; to BASIC)                                     ;
        ;-----------------------------------------------;
                ;this routine reads the local system
                ;timers
                ;every heart beat and stores the time in
                ;the heart beat buffer for use in
                ;spectral analysis
                ;


hbeat_int       proc    far     ;this procedure is not
                                ;made public
                assume  cs:cseg_sync,ds:dseg_sync
                assume  es:nothing,ss:nothing

                push    ax      ;save registers during
                                ;interrupt
                push    bx      ;
                push    cx      ;
                push    dx      ;
                push    si      ;
                push    di      ;
                push    ds      ;
```

```
push    es              ;

mov     ax,dseg_sync        ;set up segment
                        ;register for data area
mov     ds,ax               ;

inc     heartbeats          ;increment heart
                            ;   beat counter

;..........read counters and store
;             result in hb_buffer
mov     dx,con8253          ;prepare to read
                        ;hbl.clk from timer1
mov     al,40H              ;by latching
                        ;counts in timer1
out     dx,al               ;

mov     dx,timer1           ;prepare to read
                        ;the latched value
in      al,dx               ;from the timer
                        ;(low byte first)
mov     ah,al               ;save low byte
                        ;in ah
in      al,dx               ;(high byte
                        ;last)
xchg    al,ah               ;get the bytes'
                        ;order right

mov     bx,hb_wr            ;get write
                        ;pointer for hb_buffer
add     bx,bx               ;double to
                        ;point to a word
mov     hb_buffer1[bx],ax   ;and store
                        ;hbl.clk counts

;........read overflow counter from
```

```
;         timer2
mov     dx,con8253       ;prepare to read
                    ;hb2.clk from timer2
mov     al,80H           ;by latching

                         ;counts in timer2
out     dx,al            ;

mov     dx,timer2        ;prepare to read
                    ;the latched value
in      al,dx            ;from the timer
                    ;(low byte first)
mov     ah,al            ;save low byte
                         ;in ah
in      al,dx            ;(high byte
                         ;last)
xchg    al,ah            ;get the bytes'
                    ;order right in ax

mov     hb_buffer2[bx],ax        ;store
               result in hb2.clk buffer

;........increment write pointer and
;            check for buffer overflow
inc     hb_wr            ;increment write
                         ;pointer
cmp     hb_wr,1023       ;if hb_wr<=1023
jle     hb_eoi           ;then finish up

;..........reset local ptr/load disk
;          buffers for files #2,#3
;          (routine takes about 15-20
;          msec to fill disk buffer)
mov     cx,1024          ;load counter
                 ;for 1024 repetitions
lea     si,hb_buffer1    ;load local
```

```
                                  ;buffer address
            les     di,fd2ptr      ;load pointer to
                                ;disk file #2 buffer
fd21p:      movsw                  ;repeat moves
                          ;1024 times (ds:si->es:di)
            loop    fd21p          ;
            mov     cx,1024        ;load counter
                              ;for 1024 repetitions
            lea     si,hb_buffer2  ;load local
                                  ;buffer address
            les     di,fd3ptr      ;load pointer to
                                ;disk file #3 buffer
fd31p:      movsw                  ;repeat moves
                          ;1024 times (ds:si->es:di)
            loop    fd31p          ;
            mov     hb_wr,cx       ;reset write
                             ;pointer (wrap around)
            inc     hb_rd          ;increment read
                                   ;request

            ;..........acknowledge interrupt to
            ;          8259A
hb_eoi:     mov     al,20H  ;send EOI to 8259A
            out     20H,al  ;

            pop     es      ;restore registers and
            pop     ds      ;
            pop     di      ;
            pop     si      ;
            pop     dx      ;
            pop     cx      ;
            pop     bx      ;
            pop     ax      ;
            iret            ;return to place where
                            ;interrupt occurred
```

```
debugmsg2       db      'this is the end of the heart
                         beat interrupt'

hbeat_int       endp


            ;-----------------------------------------------;
            ; subroutine instint [install_interrupts]       ;
            ; (fillptr,fil2ptr,fil3ptr)                     ;
            ;-----------------------------------------------;

instint         proc    far
                public  instint
               ;public symbol allows external references
               ;es,ds vectors and must be restored movsw
               ;uses (ds:si)(es:di) addr
                assume  cs:cseg_sync,ss:basic_
                    dgroup,ds:basic_dgroup
                assume  es:basic_dgroup
                used to access interrupt

                ;..........save registers

                push    bp      ;save BASIC base pointer
                                ;    for return to BASIC
                mov     bp,sp   ;point stack pointer at
                                ;frame reference to
                                ;address of BASIC analog
                                ;data buffer

                push    ax      ;save additional
                                ;registers
                push    si      ;
                push    di      ;
```

```
push    ds          ;
push    es          ;
pushf               ;and flags

                    ;set up the segment
                    ;registers
mov     ax,dseg_sync    ;set up access
                  ;to floopy disk data ptrs
mov     es,ax           ;
assume  es:dseg_sync    ;


;..........put disk file pointers into
;           local memory
mov     di,[bp].B_fil1ptr       ;get
                 pointers from BASIC
mov     ax,[di]                 ;and
;                 save in dseg_sync areas
mov     fd1ptroff,ax            ;

mov     di,[bp].B_fil2ptr       ;
mov     ax,[di]                 ;
mov     fd2ptroff,ax            ;

mov     di,[bp].B_fil3ptr       ;
mov     ax,[di]                 ;
mov     fd3ptroff,ax            ;

mov     ax,ds           ;put segment
                      ;registers into
mov     fd1ptrseg,ax    ;pointers
mov     fd2ptrseg,ax    ;
mov     fd3ptrseg,ax    ;


                    ;set up the segment
```

```
                        ;registers
mov     ax,int_buffer
;es points to buffer area to save
mov     es,ax               ;DOS dummy
                          ;interrupt vector
assume  es:int_buffer       ;
mov     ax,0                ;ds points to
                        ;abs0 (interrupt table)
mov     ds,ax               ;
assume  ds:abs0             ;

                        ;setup access to
                        ;interrupt vectors
lea     di,save_int         ;load offset of
                              ;save_int in es,di
lea     si,IRQ3_int         ;load offset of
                              ;IRQ3_int in ds,si
cld                         ;clear direction
                         ;flag to increment ptrs
movsw                       ;save DOS dummy
                        ;interrupt vectors to be
movsw                       ;restored later
movsw                       ;now saving IRQ4
movsw                       ;


mov     IRQ3_int+2,cseg_sync    ;install
                          ;the heart beat (IRQ3)
mov     IRQ3_int,offset hbeat_int
        ;interrupt handler now
mov     IRQ4_int+2,cseg_sync    ;install
                         ;the DAC timebase (IRQ4
mov     IRQ4_int,offset tbase_int
        ;interrupt handler now
```

```
;..........initialization of buffer
           control variables

mov     ax,dseg_sync     ;setup data
          ;segment for initialization
mov     ds,ax            ;
assume  ds:dseg_sync     ;ds segment
                ;register now redefined


xor     ax,ax            ;zero ax
           ;register to initialize
mov     heartbeats,ax    ;counters
mov     sync_ctr,ax      ;
mov     ad_wr,ax         ;initialize
          ;read/write pointers to top
mov     hb_wr,ax         ;of buffer
mov     ad_rd,ax         ;
mov     hb_rd,ax         ;


;..........return to BASIC

popf            ;restore flags
pop     es      ;restore additional
                 registers
pop     ds      ;
pop     di      ;
pop     si      ;
pop     ax      ;

pop     bp      ;restore BASIC's base
                ;pointer and
ret     6       ;delete 3 parameters (6
                ;bytes) from the stack
                ;and return to the
```

```
                                        ;calling routine

debugmsg3       db      'this is the end of the
                        interrupt installation'

instint         endp


                ;--------------------------------------;
                ; subroutine exstint (exstall_         ;
                ; interrupts)                          ;
                ;--------------------------------------;

exstint         proc    far
                public  exstint ;public symbol allows
                                   ;external references
                assume  cs:cseg_sync,ss:basic_dgroup
                assume  ds:int_buffer,es:abs0
                ;es,ds used to access interrupt
                ;vectors and must be restored
                ;movsw uses (ds:si)(es:di) addr

                ;..........save registers

                push    bp      ;save BASIC base pointer
                                ;    for return to BASIC
                mov     bp,sp   ;point stack pointer at
                                ;     frame reference to
                                ;access arguments passed
                                ;   by BASIC (none here)

                push    ax      ;save additional
                                ;registers
```

```
push    si          ;
push    di          ;
push    ds          ;
push    es          ;
pushf               ;and flags

                    ;set up the segment
                    ;registers as assumed
mov     ax,0                ;es points to
                    ;abs0 (interrupt table)
mov     es,ax               ;
mov     ax,int_buffer       ;ds points to
                    ;buffer area to save
mov     ds,ax               ;DOS dummy
                    ;interrupt vector

                    ;setup access to
                          ;interrupt vectors
lea     di,IRQ3_int         ;load offset of
                          ;IRQ3_int in es,di
lea     si,save_int         ;load offset of
                          ;save_int in ds,si
cld                         ;clear direction
                     ;flag to increment ptrs
movsw                       ;restore DOS
                    ;dummy interrupt vectors
movsw                       ;for IRQ3
movsw                       ;and IRQ4
movsw                       ;


;..........return to BASIC

popf                ;restore flags
pop     es          ;restore additional
                    ;registers
```

```
                pop     ds      ;
                pop     di      ;
                pop     si      ;
                pop     ax      ;

                pop     bp      ;restore BASIC's base
                                ;pointer and
                ret     0       ;delete 0 parameters (0
                                ;bytes) from the stack
                                ;and return to the
                                ;calling routine

debugmsg4       db      'this is the end of the
                         interrupt exstallation'

exstint         endp



                ;--------------------------------------;
                ; subroutine rdbeat (heartbeats,sync_  ;
                ; pulses)                              ;
                ;--------------------------------------;


rdbeat          proc    far
                public rdbeat   ;public symbol allows
                external references
                assume cs:cseg_sync,es:dseg_sync
                assume ds:basic_dgroup,ss:basic_dgroup


                ;..........save registers
```

```
        push    bp      ;save BASIC base poin
                      ;ter for return to BASIC
        mov     bp,sp   ;point stack pointer at
                        ;frame reference to
                        ;access arguments passed
                        ;by BASIC (one here)

        push    ax      ;save additional
                         registers
        push    di      ;
        push    es      ;

        mov     ax,dseg_sync    ;set up segment
                          register for data area
        mov     es,ax           ;


        mov     ax,heartbeats           ;get
                        ;beats from local memory
        mov     di,[bp].BASIC_beats     ;
        mov     [di],ax                 ;send
                               ;beats to BASIC

        mov     ax,sync_ctr             ;get
                      ;sync pulses from local
        mov     di,[bp].BASIC_syncs     ;memory
        mov     [di],ax                 ;send
                         ;sync pulses to BASIC


;..........return to BASIC

        pop     es      ;restore additional
                         registers
        pop     di      ;
        pop     ax      ;
```

```
                    pop     bp        ;restore BASIC's base
                                      ;pointer,
                    ret     4         ;delete 2 parameters (4
                                      ;bytes) from the stack
                                      ;and return to the
                                      ;calling routine

debugmsg5           db      'this is the end of the heart
                             beat read routine'

rdbeat   endp


                    ;---------------------------------------;
                    ; subroutine rdbuf (BASIC_               ;
                    ; ptr,whichbuff)                         ;
                    ;---------------------------------------;
                            ;this routine dumps a buffer
                            ;from the
                            ;assembly routine data area to a
                            ;BASIC array
                            ;pointed to by BASIC_ptr;
                            ;whichbuff selects
                            ;the assembler buffer to be
                            ;dumped.
                            ;choices of buffer are:
                            ;    0 - ad_buffer       (bytes)
                            ;    1 - hb_buffer1      (words)
                            ;    2 - hb_buffer2      (words)

rdbuf               proc    far
                    public rdbuf      ;public symbol allows
                                      ;external references
                    assume cs:cseg_sync,es:basic_dgroup
                    assume ds:basic_dgroup,ss:basic_dgroup
```

```
;..........save registers

push    bp        ;save BASIC base pointer
                  ;for return to BASIC
mov     bp,sp     ;point stack pointer at
                  ;frame reference to
                  ;access arguments passed
                  ;by BASIC (one here)

push    ax        ;save additional
                  ;registers
push    cx        ;
push    si        ;
push    di        ;
push    ds        ;
push    es        ;
pushf             ;and flags


;..........get pointers from BASIC
mov     di,[bp].whichbuff       ;get
            ;buffer choice from BASIC
mov     ax,[di]                 ;

mov     di,[bp].BASIC_ptr
;get pointer to BASIC's data area
mov     di,[di]         ;and put pointer
                        ;into di


;..........set up extra segment register
;          and counter
mov     cx,dseg_sync    ;set up segment
                  register for data area
```

```
                mov      ds,cx              ;
                assume   ds:dseg_sync
                mov      cx,1024            ;load counter
                                   ;with number of objects


                ;..........select buffer here and place
                ;          pointer in si
                or       ax,ax              ;compare
                                          ;selector with 0
                jz       rd_adbuf
                ;if zero (select =0) read ad_buffer
                dec      ax                 ;decrement to
                                        ;see if select was 1
                jz       rd_hbbuf1
                ;if zero (select =1) read hb_buffer1
                dec      ax                 ;decrement to
                                        ;see if select was 2
                jz       rd_hbbuf2
                ;if zero (select =2) read hb_buffer2
                jmp      rdbuf_end
                ;not a valid buffer, so return to BASIC

rd_adbuf:       lea      si,ad_buffer       ;point source
                                       ;index to ad_buffer
                jmp      move_dta_byte      ;

rd_hbbuf1:      lea      si,hb_buffer1      ;point source
                                       ;index to hb_buffer1
                jmp      move_dta_word      ;

rd_hbbuf2:      lea      si,hb_buffer2      ;point source
                                       ;index to hb_buffer2
                jmp      move_dta_word      ;
```

```
                ;..........move byte data from local
                ;          storage to BASIC array
move_dta_byte:  xor     ah,ah   ;zero upper byte of ax

                cld             ;clear direction flag to
                                ;increment si,di by 2
byt_lp:         lodsb           ;move data bytes from
                                ;local storage (ds:si)
                stosw           ;and store as a word in
                                ;BASIC's area (es:di)
                loop    byt_lp  ;
                jmp     rdbuf_end ;finished


                ;..........move word data from local
                ;          storage to BASIC array
move_dta_word:  cld             ;clear direction flag to
                                ;increment si,di by 2
wd_lp:          movsw           ;get data word from
                                ;local storage (ds:si)
                loop    wd_lp   ;and store as a word in
                                ;BASIC's area (es:di)


                ;..........return to BASIC

rdbuf_end:      popf            ;restore flags
                pop     es      ;restore additional
                                ;registers
                pop     ds      ;
                pop     di      ;
                pop     si      ;
                pop     cx      ;
                pop     ax      ;

                pop     bp      ;restore BASIC's base
```

```
                                  ;pointer,
                  ret     4       ;delete 2 parameters (4
                                  ;bytes) from the stack
                                  ;and return to the
                                  ;calling routine

debugmsg6         db      'this is the end of the buffer
                           read routine'

rdbuf   endp


        ;-----------------------------------------------;
        ; subroutine rdptrs (BASIC_adwr,BASIC_          ;
        ; hbwr,adflag,hbflag)                           ;
        ;-----------------------------------------------;
                  ;this routine returns pointers
                  ;appropriate
                  ;arrays returned to BASIC through rdbuf
                  ;this means the pointers are subtracted
                  ;from 1025
                  ;since the buffers have decrementing
                  ;pointers
                  ;whereas the BASIC data has incrementing
                  ;pointers
                  ;the flags indicate whether or not the
                  ;respective
                  ;disk file buffers have been filled and
                  ;therefore require
                  ;service (eg, a BASIC PUT command to
                  ;store the buffer on disk)

rdptrs            proc    far
                  public rdptrs   ;public symbol allows
                                  ;external references
                  assume cs:cseg_sync,es:dseg_sync
```

```
assume ds:basic_dgroup,ss:basic_dgroup


;..........save registers

push    bp          ;save BASIC base pointer
                    ;for return to BASIC
mov     bp,sp       ;point stack pointer at
                    ;frame reference to
                    ;access arguments passed
                    ;by BASIC (one here)

push    ax          ;save additional
                    ;registers
push    di          ;
push    es          ;

mov     ax,dseg_sync    ;set up segment
                     ;register for data area
mov     es,ax           ;


mov     ax,ad_wr              ;get write
                     ;pointer for A/D buffer
mov     di,[bp].BASIC_adwr    ;and send
                              ;to BASIC
mov     [di],ax               ;

mov     ax,hb_wr                 ;get
                  ;write pointer for heart
mov     di,[bp].BASIC_hbwr       ;beat
                ;buffer and send to BASIC
mov     [di],ax                  ;

mov     ax,ad_rd                 ;get
                ;disk file flag for A/D
```

```
                mov     di,[bp].adflag          ;buffer
                                          ;and send to BASIC
                mov     [di],ax                 ;

                mov     ax,hb_rd                ;get
                            ;disk file flag for heart
                mov     di,[bp].hbflag          ;beat
                            ;buffers and send to BASIC
                mov     [di],ax                 ;

                ;..........return to BASIC

                pop     es      ;restore additional
                                ;registers
                pop     di      ;
                pop     ax      ;

                pop     bp      ;restore BASIC's base
                                ;pointer,
                ret     8       ;delete 4 parameters (8
                                ;bytes) from the stack
                                ;and return to the
                                ;calling routine

debugmsg7       db      'this is the end of the pointer
                         read routine'

rdptrs  endp


cseg_sync       ends
                end
; module gwindowl.asm - a collection of routines useful
;                       for preparing data
;                       for the fast graphics routine.
;
```

```
;        subroutines:
;
;                dwindow(xmin,xmax,ymin,ymax) - establish
;                data value limits corresponding to
;                    screen window.
;
;                swindow(xmin,xmax,ymin,ymax) - establish
;                 screen boundaries for data to be
;                 plotted.
;
;                clrwindw - clear contents of present
;                   window
;
;                axes - prepare axes for current window
;                                    (no tick marks yet)
;                        (first version: only draws a box
;                         around window)
;
;                scaler(indata_ptr,outdata_ptr,numval) -
;                  scale data to fit into window requires
;                                  correct initialization
;                                       using dwindow
;                                       and swindow
;                        (first version: only scales y-
;                             coordinate with dwindow)
;                        (              x coordinate
;                            scaled by numval)
;                        (              maximum y-value
;                               is plotted)
;
;
;-------------------------------------------------------
;
;                arguments passed by BASIC
;
;
```

```
;       indata_ptr       - offset of BASIC array
;                      containing y-coordinates of
;                         points to be plotted
;       outdata_ptr      - offset of BASIC array
;                  containing scaled y-coordinates
;       numval           - number of values to plot
;
;--------------------------------------------------------


                ;..........screen memory definition

screen_memory   segment at 0B800H
even_pixels     db      8000 dup(?)     ;pixels with
                                  ;even y-coordinates
                org     2000H           ;beginning of
                                   ;high screen memory
odd_pixels      db      8000 dup(?)     ;pixels with odd
                                        ;y-coordinates
screen_memory   ends


                ;.........local memory definitions

dseg_wind       segment             ;valid default values
                                    ;present at startup

xmin_s          dw      0           ;minimum screen ordinate
                                    ;for window
xmax_s          dw      639         ;maximum screen ordinate
                                    ;for window
ymin_s          dw      0           ;minimum screen abscissa
                                    ;for window
ymax_s          dw      199         ;maximum screen abscissa
                                    ;for window
```

```
xmin_d      dw    0       ;minimum data ordinate
                          ;for window
xmax_d      dw    16384   ;maximum data ordinate
                          ;for window
ymin_d      dw    0       ;minimum data abscissa
                          ;for window
ymax_d      dw    16384   ;maximum data abscissa
                          ;for window

ulh_cor     dw    0       ;offset for upper left
                          ;hand corner of screen
urh_cor     dw    79      ;offset for upper right
                          ;hand corner of screen
llh_cor     dw    3EF0H   ;offset for lower left
                          ;hand corner of screen
lrh_cor     dw    3F3FH   ;offset for lower right
                          ;hand corner of screen

outptr      dw    ?       ;pointer to output array
                          ;in BASIC (must be
                          ;at least as large as
                          ;input array)
rndoff      dw    ?       ;roundoff correction (if
                          ;fraction>.5 round up)
numvalt     dw    ?       ;save number of points
                          ;in input array for xpass
bx_last     dw    ?       ;save pointer during x-
                          ;scaling to allow
                          ;use of largest y per x
                          ;pixel

dseg_wind   ends
```

```
;-------------------------------------------;
; define structures for passing arguments from ;
; BASIC                                      ;
;-------------------------------------------;

                ; subroutines
                   dwindow/swindow(xmin,xmax,ymin,ymax)
frame_lim       struc               ;define structure
savebp1         dw      ?           ;caller's base pointer
saveret1        dd      ?           ;return offset and
                                    ;segment pushed by BASIC
ymax            dw      ?           ;maximum abscissa
                                ;(screen or data coordinate)
ymin            dw      ?           ;minimum abscissa
                                ;(screen or data coordinate)
xmax            dw      ?           ;maximum ordinate
                                 ;(screen or data coordinate)
xmin            dw      ?           ;minimum ordinate
                                 ;(screen or data coordinate)
frame_lim       ends


                ; subroutine scaler(indata_ptr,outdata_
                ; ptr,numval)
frame_scl       struc               ;define structure
savebp2         dw      ?           ;caller's base pointer
saveret2        dd      ?           ;return offset and
                                    ;segment pushed by BASIC
numval          dw      ?           ;number of values in
                                    ;BASIC's data array
outdata_ptr     dw      ?           ;scaled values are
                                    ;passed to a BASIC
                                    ;array pointed to by
                                   ;this pointer(for fgraph)
indata_ptr      dw      ?           ;values to be graphed
                                   ;are passed from a BASIC
```

```
                                ;array pointed to by
                                ;this pointer.
frame_scl       ends

                ;...........subroutines' code begins here

cseg_gr segment 'code'
dgroup  group   data,stack,const,heap,memory
            ;defining link to BASIC

            ;---------------------------------------------;
            ; subroutine dwindow(xmin,xmax,ymin,ymax)     ;
            ;---------------------------------------------;
                ;subroutine to establish data value
                ;limits
                ;corresponding to screen window.

dwindow         proc    far
                public  dwindow
               ;public symbols allow external references
                assume  cs:cseg_gr,ds:dgroup
               ;BASIC defines regs
                assume  ss:dgroup,es:dseg_wind

            push    bp      ;save base pointer for the
                            ;return to BASIC
            mov     bp,sp   ;point stack pointer at frame
                            ;structure
```

```
                ;..........save additional registers and
                ;          set up extra data seg
        push    ax        ;
        push    di        ;
        push    es        ;

        mov     ax,dseg_wind    ;set up extra data
                                ;segment as assumed
        mov     es,ax           ;


                ;....get specifications for window from
                ;    BASIC and store locally

        mov     di,[bp].ymax    ;
        mov     ax,[di]         ;
        mov     ymax_d,ax       ;

        mov     di,[bp].ymin    ;
        mov     ax,[di]         ;
        mov     ymin_d,ax       ;

        mov     di,[bp].xmax    ;
        mov     ax,[di]         ;
        mov     xmax_d,ax       ;

        mov     di,[bp].xmin    ;
        mov     ax,[di]         ;
        mov     xmin_d,ax       ;


                ;..........restore all registers which
                ;          were corrupted
        pop     es              ;
        pop     di              ;
        pop     ax              ;
```

```
            pop     bp              ;restore BASIC base
                                ;pointer before returning
            ret     8               ;delete 4 parameter
                                ;addresses (8 bytes) from
                                    ;stack and return to
                                    ;calling routine
    dwindow endp


            ;-------------------------------------------------;
            ; subroutine swindow(xmin,xmax,ymin,ymax)         ;
            ;-------------------------------------------------;
                    ;subroutine to establish absolute screen
                    ;coordinate limits
                    ;corresponding to screen window.

    swindow         proc    far
                    public  swindow ;public symbols allow
                    external references
                    assume  cs:cseg_gr,ss:dgroup
                    ;BASIC defines regs
                    assume  ds:dseg_wind,es:dgroup


            push    bp      ;save base pointer for the
                            ;return to BASIC
            mov     bp,sp   ;point stack pointer at frame
                            ;structure


                    ;..........save additional registers and
                    ;          set up extra data seg
            push    ax      ;
            push    cx      ;
```

```
        push    dx          ;
        push    di          ;
        push    ds          ;

        mov     ax,dseg_wind        ;set up extra data
                                    ;segment as assumed
        mov     ds,ax               ;


                ;....get specifications for window from
                ;    BASIC and store locally
                ;........first y coordinate ranges
        mov     di,es:[bp].ymax ;
        mov     ax,es:[di]                  ;
        cmp     ax,199              ;make sure ymax_s <=199
        jg      y_bad               ;use default value if
                                    ;value sent is bad
        mov     ymax_s,ax           ;

        mov     di,es:[bp].ymin ;
        mov     ax,es:[di]                  ;
        mov     ymin_s,ax           ;

                ;..........y range limits examined
        add     ax,8                ;make sure that ymax
                            ;exceeds ymin by at least 8
        cmp     ax,ymax_s           ;
        jng     y_ok                ;if ymax_s <= ymin_s+8
y_bad:  mov     ax,199              ;then set ymax_s,ymin_s
                                    ;to default values
        mov     ymax_s,ax           ;ymax_s default=199
        xor     ax,ax               ;ymin_s default=0
        mov     ymin_s,ax                   ;


                ;..........x coordinate ranges set up
```

```
y_ok:   mov     di,es:[bp].xmax ;
        mov     ax,es:[di]                ;
        cmp     ax,639          ;make sure xmax_s <=639
        jg      x_bad           ;use default value if
                                ;value sent is bad
        mov     xmax_s,ax       ;

        mov     di,es:[bp].xmin ;
        mov     ax,es:[di]                ;
        mov     xmin_s,ax       ;

                ;..........x range limits examined
        cmp     ax,xmax_s       ;make sure that xmax
                                ;exceeds xmin
        jnge    x_ok            ;if xmax_s < xmin_s
x_bad:  mov     ax,639          ;then set xmax_s,xmin_s
                                ;to default values
        mov     xmax_s,ax       ;xmax_s default=199
        xor     ax,ax           ;xmin_s default=0
        mov     xmin_s,ax                 ;


                ;..........set up the pointers to the
                ;           four screen corners

                ; --ymin
x_ok:   xor     dx,dx           ;put lowest screen
                     ;memory location (=0) into dx
        mov     ax,ymin_s       ;first calculate y
                        ;contribution to offset of
        shr     ax,1            ;upper corners by
                      multiplying (ymin/2) by 80.
        jnc     y0_even         ;if ymin was not even
        mov     dx,2000H        ;then the upper corners
                                ;are odd pixels (2000H)
```

```
y0_even:mov     cl,80               ;[promised
                                    ;multiplication by 80]
        mul     cl                  ;
        add     dx,ax               ;y contribution to
                                    ;offset is here
        mov     ulh_cor,dx          ;save partial result
        mov     urh_cor,dx          ;

                ; --ymax
        xor     dx,dx               ;put lowest screen
                                ;memory location (=0) into dx
        mov     ax,ymax_s           ;first calculate y
                                 ;contribution to offset of
        shr     ax,1                ;lower corners by
                                ;multiplying (ymax/2) by 80.
        jnc     y1_even             ;if ymax was not even
        mov     dx,2000H            ;then the upper corners
                                    ;are odd pixels (2000H)
y1_even:mov     cl,80               ;[promised
                                    ;multiplication by 80]
        mul     cl                  ;
        add     dx,ax               ;y contribution to
                                    ;offset is here
        mov     llh_cor,dx          ;save partial result
        mov     lrh_cor,dx          ;

        mov     ax,xmin_s           ;x contribution is
                                    ;xmin/8
        mov     cl,3                ;calculated by shifting
                                    ;right 3 bits
        shr     ax,cl               ;and
        add     ulh_cor,ax          ;adding the result to
                                  ;the stored partial result
        add     llh_cor,ax          ;

        mov     ax,xmax_s           ;x contribution is
```

```
                                  xmin/8
        mov     cl,3              ;calculated by shifting
                                  ;right 3 bits
        shr     ax,cl             ;and
        add     urh_cor,ax        ;adding the result to
                                ;the stored partial result
        add     lrh_cor,ax        ;

                ;..........restore all registers which
                ;          were corrupted
        pop     ds                ;
        pop     di                ;
        pop     dx                ;
        pop     cx                ;
        pop     ax                ;

        pop     bp                ;restore BASIC base
                              ;pointer before returning
        ret     8                 ;delete 4 parameter
                             ;addresses (8 bytes) from
                                  ;stack and return to
                                  ;calling routine
swindow endp

                ;---------------------------------------;
                ; subroutine clrwindw                   ;
                ;---------------------------------------;
                        ;subroutine to clear
                        ;the screen window.

clrwindw        proc    far
                public  clrwindw ;public symbols allow
                                    ;external references
```

```
                assume   cs:cseg_gr,ss:dgroup
                ;BASIC defines regs
                assume   ds:dseg_wind,es:screen_memory

        push    bp      ;save base pointer for the
                        ;return to BASIC
        mov     bp,sp   ;point stack pointer at frame
                        ;structure

                ;..........save additional registers and
                ;          set up data segments
        push    ax      ;
        push    bx      ;
        push    cx      ;
        push    dx      ;
        push    si      ;
        push    di      ;
        push    ds      ;
        push    es      ;

                ;..........set up data segments as
                ;          assumed
        mov     ax,dseg_wind    ;
        mov     ds,ax           ;
        mov     ax,screen_memory;
        mov     es,ax           ;

                ;..........clear screen by zeroing out
                ;          graphics memory
                ;               register usage:
                ;               ax - marker for
                ;                 rightmost column
```

```
        ;                   bh - # x bytes
        ;                   bl - pixel mask
        ;                   cx - y
        ;                     coordinate counter
        ;                   dx - # y lines
        ;                   si - offset of
        ;                     top of column
        ;                   di - offset of
        ;                     present byte
        ;....first clear leftmost part of window
mov     dx,ymax_s           ;compute number of
                            ;vertical lines
sub     dx,ymin_s           ;
inc     dx                  ;and save in dx

mov     ax,urh_cor          ;compute number of
                            ;horizontal bytes
sub     ax,ulh_cor          ;(a number 1-79)
mov     bh,al               ;and save in bh
xor     ax,ax               ;clear ax register to
                          ;indicate clearing of all
                            ;columns except the
                            ;rightmost one


        ;..........set up to blank leftmost
        ;           column
mov     cx,xmin_s           ;compute mask for
                          ;blanking leftmost column
call    mask0               ;

lea     di,even_pixels      ;get offset of
add     di,ulh_cor          ;upper left hand corner
                             of window
mov     si,di               ;save location in si
```

```
                    ;..........blank all columns except
                    ;          rightmost
nxt_col:call        clr_col         ;
        xor         bl,bl           ;subsequent columns
                             ;blank all bits (bl mask=0)
        inc         si              ;compute offset of
                                    ;present column
        mov         di,si           ;and load into di
        dec         bh              ;see if there are any
                                    ;columns left
        jnz         nxt_col         ;

                    ;..........blank rightmost column
        mov         cx,xmax_s       ;compute mask for
                                    ;rightmost column
        inc         cx              ;include rightmost pixel
        and         cl,7            ;using cx mod 8
        mov         bl,0FFH         ;put mask in bl
        jz          mask_r          ;if cx mod 8 <>0 then
        shr         bl,cl           ;shift mask
                                    ;appropriately
        jmp         lst_clr         ;
mask_r: xor         bl,bl           ;set bl mask to blank
                                    ;all bits
lst_clr:call        clr_col         ;clear rightmost column


                    ;..........restore all registers which
                    ;          were corrupted
        pop         es              ;
        pop         ds              ;
        pop         di              ;
        pop         si              ;
        pop         dx              ;
        pop         cx              ;
```

```
            pop     bx                  ;
            pop     ax                  ;

            pop     bp                  ;restore BASIC base
                                        ;pointer before returning
            ret     0                   ;delete 0 parameter
                                        ;addresses (0 bytes) from
                                        ;stack and return to
                                        ;calling routine
clrwindw endp


                    ;-------------------------------------;
                    ; subroutine axes                     ;
                    ;-------------------------------------;
                            ;subroutine to draw a box
                            ;enclosing the screen window.

axes                proc    far
                    public  axes    ;public symbols allow
                                    ;external references
                    assume  cs:cseg_gr,ss:dgroup
                    ;BASIC defines regs
                    assume  ds:dseg_wind,es:screen_memory


            push    bp      ;save base pointer for the
                            ;return to BASIC
            mov     bp,sp   ;point stack pointer at frame
                            ;structure


                    ;..........save additional registers and
                    ;          set up data segments
```

```
        push    ax      ;
        push    bx      ;
        push    cx      ;
        push    dx      ;
        push    si      ;
        push    di      ;
        push    ds      ;
        push    es      ;


                ;..........set up data segments as
                ;          assumed
        mov     ax,dseg_wind    ;
        mov     ds,ax           ;
        mov     ax,screen_memory;
        mov     es,ax           ;


                ;..........draw box screen by setting
                ;          appropriate bits
                ;              register usage:
                ;              ax - marker for
                ;                rightmost column
                ;              bh - # x bytes
                ;              bl - pixel mask
                ;              cx - y
                ;                coordinate counter
                ;              dx - # y lines
                ;              si - offset of
                ;                top of column
                ;              di - offset of
                ;                present byte
                ;....first calculate number of
                     vertical,horizontal counts
        mov     dx,ymax_s       ;compute number of
                                ;vertical lines
```

```
        sub     dx,ymin_s          ;
        inc     dx                 ;and save in dx

        mov     ax,urh_cor         ;compute number of
                                   ;horizontal bytes
        sub     ax,ulh_cor         ;(a number 1-79)
        mov     bh,al              ;and save in bh


                ;..........left edge of box
        lea     di,even_pixels     ;get offset of
        add     di,ulh_cor         ;upper left hand corner
                                   ;of window

        mov     cx,xmin_s          ;compute mask to draw
                                   ;left end of top line
        call    mask0              ;[mask0 gives pixels to
                                   ;left of x coordinate]
        xor     bl,0FFH            ;[requiring
                                   ;complementation here]
        or      es:[di],bl         ;

        mov     cx,xmin_s          ;compute mask for
                                 ;setting leftmost box edge
        call    mask1              ;
        call    drw_ln             ;draw the left most
                                   ;border of the box

        lea     di,even_pixels     ;get offset of
        add     di,llh_cor         ;lower left hand corner
                                   ; of window
        mov     cx,xmin_s          ;compute mask to draw
                                  ;left end of bottom line
        call    mask0              ;[mask0 gives pixels to
                                   ;left of x coordinate]
        xor     bl,0FFH            ;[requiring
```

```
                                  ;complementation here]
        or      es:[di],bl        ;

                ;..........bottom edge of box
        mov     bl,bh             ;save number of
                                  ;horizontal bytes in bl
        call    hbar              ;draw horizontal bar

                ;..........top edge of box
        mov     bh,bl             ;get number of
                               ;horizontal bytes from bl
        lea     di,even_pixels    ;get offset of
        add     di,ulh_cor        ;upper left hand corner
                                  ;of window
        call    hbar              ;draw horizontal bar

                ;..........right edge of box
        lea     di,even_pixels    ;get offset of
        add     di,urh_cor        ;upper left hand corner
                                  ;of window

        mov     cx,xmax_s         ;compute mask to draw
                                  ;right end of top line
        call    mask0             ;
        or      es:[di],bl        ;

        mov     cx,xmax_s         ;compute mask for
                               ;setting rightmost box edge
        call    mask1             ;
        call    drw_ln            ;set rightmost box edge

        lea     di,even_pixels    ;get offset of
        add     di,lrh_cor        ;lower right hand corner
                                   ;of window
```

```
        mov     cx,xmax_s       ;compute mask to draw
                               ;right end of bottom line
        call    mask0           ;
        or      es:[di],bl      ;


                ;..........restore all registers which
                ;          were corrupted
        pop     es              ;
        pop     ds              ;
        pop     di              ;
        pop     si              ;
        pop     dx              ;
        pop     cx              ;
        pop     bx              ;
        pop     ax              ;


        pop     bp              ;restore BASIC base
                              ;pointer before returning
        ret     0               ;delete 0 parameter
                               ;addresses (0 bytes) from
                                ;stack and return to
                                ;calling routine
axes endp



        ;----------------------------------------------;
        ; subroutine scaler(indata_ptr,outdata_        ;
        ; ptr,numval)                                  ;
        ;----------------------------------------------;
                ;subroutine to scale data values within
                ;limits
                ;corresponding to data window. As a.
                ;convenience,
```

```
                        ;the data is inverted so ymax_d is at
                        ;top of
                        ;the window (screen values increase
                        ;towards
                        ;bottom of the screen)
                        ;
                        ;scaling occurs in two passes: first y
                        ;is scaled, then x
scaler                  proc    far
                        public  scaler  ;public symbols allow
                                         external references
                        assume  cs:cseg_gr,es:dgroup
                        ;BASIC defines regs
                        assume  ss:dgroup,ds:dseg_wind


                push    bp      ;save base pointer for the
                                ;return to BASIC
                mov     bp,sp   ;point stack pointer at frame
                                ;structure


                        ;..........save additional registers and
                        ;          set up extra data seg
                push    ax      ;
                push    bx      ;
                push    cx      ;
                push    dx      ;
                push    si      ;
                push    di      ;
                push    ds      ;

                mov     ax,dseg_wind    ;set up extra data
                                        ;segment as assumed
                mov     ds,ax           ;
```

```
;....get data from BASIC point by point
;                  and scale according to
;         data window. (use di,bx as
;         holding registers)

        mov     si,es:[bp].outdata_ptr
                ;get pointer for scaled data output
        mov     si,es:[si]          ;pointer is now in si
        mov     outptr,si           ;save output pointer

        mov     si,es:[bp].numval
                ;get number of points to scale into cx
        mov     cx,es:[si]      ;
        mov     numvalt,cx      ;save value for second
                                ;pass

        mov     si,es:[bp].indata_ptr
                ;get pointer to BASIC's array of data
        mov     si,es:[si]              ;pointer for
                                  ;input is now in si
        mov     di,outptr               ;pointer for
                                  ;output is now in di

        mov     bx,ymax_s       ;put screen scale into
                                ;bx
        sub     bx,ymin_s       ;

        mov     ax,bx           ;use half screen scale
                              ;as a roundoff correction
        shr     ax,1            ;
        mov     rndoff,ax       ;

        mov     bp,ymax_d       ;put data scale into bp
        sub     bp,ymin_d       ;
```

```
getval: mov     ax,es:[si]       ;get data value from
                                 ;BASIC

        cmp     ax,ymin_d        ;if less than ymin_d
        jle     minval           ;then use minimum value
        sub     ax,ymax_d        ;if greater than ymax_d
        jge     maxval           ;then use maximum value
        neg     ax               ;ax now has distance
                                 ;from full scale

        mul     bx               ;multiply by screen
                                 ;scale (corrupts dx)
        add     ax,rndoff        ;add roundoff correction
        jnc     div_d            ;if no carry (ax,dx)
                                 ;pair is correct
        inc     dx               ;otherwise increment dx
                                 ;(carry from add)
div_d:  div     bp               ;and divide by data
                                 ;scale
        add     ax,ymin_s        ;add screen offset value
                                 ;to get final scaled
        jmp     nextval          ;value

maxval: mov     ax,ymax_s        ;insert maximum value
        jmp     nextval          ;

minval: mov     ax,ymin_s        ;insert minimum value
        jmp     nextval          ;

nextval:mov     es:[di],ax       ;store y-scaled result
                                 ;in BASIC output array
        inc     si               ;point to next data
                             ;value (integer is 2 bytes)
        inc     si               ;
        inc     di               ;point to next output
                                 ;point for y-scaled data
```

```
        inc     di              ;
        loop    getval          ;if cx shows points
                                ;remain, scale them


                ;..........scale x-axis
        mov     di,outptr       ;point di to beginning
                                ;of output array
        mov     cx,numvalt      ;restore counter for
                                ;number of points

        mov     bp,xmax_s       ;put screen scale into
                                ;bp
        sub     bp,xmin_s       ;

        mov     bx,639          ;initialize bx_last to
                                ;rightmost pixel
        mov     bx_last,bx      ;

        xor     ax,ax           ;zero ax,bx to start
        xor     bx,bx           ;bx points to x-unscaled
                                ;source

get_ysc: mov    si,es:[di][bx]  ;get current value y
                                ;scaled value into si

        mov     ax,bx           ;calculate twice x-
                                ;coordinate plus 1
        inc     ax              ;(gives proper roundoff)

        mul     bp              ;multiply by screen
                                ;scale (corrupts dx)
div_x:  div     numvalt         ;scale by number of
                                ;input points
        and     ax,0FFFEH       ;trim off lsb for
                                ;aligned access to words
```

```
        xchg    ax,bx           ;save source ptr in ax,
                                ;using bx to point to
                                ;offset of destination
                                ;(which is a word)
        cmp     bx,bx_last      ;see if we are on the
                                ;same x-coordinate
        jne     y_save          ;if not put a valid
                             ;abcissa at this coordinate
        cmp     es:[di][bx],si  ;compare yscaled value
                                ;to last yscaled value
        jle     y_more          ;stored. if y was
                          ;greater or equal then keep it
y_save: mov     es:[di][bx],si  ;else store yscaled
                              ;value in output array
        mov     bx_last,bx      ;save current
                                ;destination pointer

y_more: xchg    bx,ax           ;restore bx register

        inc     bx              ;point to next input
                                ;point
        inc     bx              ;
        loop    get_ysc         ;continue scaling x
                               ;until counter cx is zero



                ;..........restore all registers which
                ;          were corrupted
        pop     ds              ;
        pop     di              ;
        pop     si              ;
        pop     dx              ;
        pop     cx              ;
        pop     bx              ;
```

```
        pop     ax              ;
        pop     bp              ;restore BASIC base
                                ;pointer before returning
        ret     6               ;delete 3 parameter
                                ;addresses (6 bytes) from
                                ;stack and return to
                                ;calling routine
scaler  endp



                ;---------------------------------------;
                ; utility routines local to the window ;
                ; module                                ;
                ;---------------------------------------;

                ;..........utility procedure for fast
                ;          clearing of vertical cols
clr_col proc    near

        mov     cx,dx           ;set up counter for
                                ;clearing first column
clr_lp: and     es:[di],bl      ;clear a graphics byte
                                ;using mask
        xor     di,2000H        ;switch even/odd pixel
        test    di,2000H        ;if odd pixel go to
loop                            ;     statement
        jnz     go_clr          ;
        add     di,80           ;go to next even/odd
                                ;pair
go_clr: loop    clr_lp          ;continue clearing this
                                ;column
        ret                     ;

clr_col endp
```

```
                ;..........utility procedure for fast
                ;          drawing of vertical lines
drw_ln  proc    near

        mov     cx,dx              ;set up counter for
                                   ;clearing first column
drw_lp: or      es:[di],bl         ;set a graphics bit
                                   ;using mask
        xor     di,2000H           ;switch even/odd pixel
        test    di,2000H           ;if odd pixel go to loop
                                   ;statement
        jnz     go_drw             ;
        add     di,80              ;go to next even/odd
                                   ;pair
go_drw: loop    drw_lp             ;continue clearing this
                                   ;column
        ret                        ;

drw_ln  endp


                ;..........utility for fast drawing of
                ;          horizontal lines
hbar    proc    near       ;requires di to have byte before
                           ;first byte of line
                           ;bh is used as a decrementing
                           ;byte counter for number
                           ;of bytes drawn

        dec     bh                 ;check to make sure at
                                   ;least one byte to plot
        jz      hbar_ok            ;if bh=0 then done
```

```
hbar_lp:inc     di                      ;go to next byte
        mov     byte ptr es:[di],0FFH   ;set byte
        dec     bh                      ;decrement number of
                                        ;bytes remaining
        jnz     hbar_lp                 ;continue if more bytes
                                        ;need to be drawn

hbar_ok:ret                             ;

hbar    endp



                ;..........utility procedure for
                ;          computing bit mask for clears
mask0   proc    near    ;uses value in cx to compute bit
                        ;mask in bl

        and     cl,7                    ;using cx mod 8
        mov     bl;0FFH                 ;put mask in bl
        jz      mask0_ok                ;if cx mod 8 <>0 then
        shr     bl,cl                   ;shift mask
                                        ;appropriately
mask0_ok:xor    bl,0FFH                 ;complement mask to set
                                        ;bits to be retained
        ret

mask0   endp



                ;..........utility procedure for
                ;          computing bit mask for drawing
mask1   proc    near    ;uses value in cx to compute bit
                        ;mask in bl
```

```
        and     cl,7                ;using cx mod 8
        mov     bl,80H              ;put mask in bl
        jz      maskl_ok            ;if cx mod 8 <>0 then
        shr     bl,cl               ;shift mask
                                    ;appropriately
maskl_ok:ret

maskl   endp


cseg_gr ends
        end

; subroutine fgraph (data_ptr,numval,x_coord,line_type)
;       called from BASIC this routine graphs an array
;       on the screen
;       this routine is designed to allow rapid access
;       to the screen to allow
;       real time graph generation.
;

;---------------------------------------------------
;
;                arguments passed by BASIC
;
;
;       data_ptr        - offset of BASIC array
;                         containing y-coordinates of
;                         points to be plotted
;       numval          - number of values to plot
;       x_coord         - absolute (screen) x coordinate
;                         of first point
;                         succeeding values are plotted
;                         at succeeding pixels
;       line_type       - if 0 then just plot points
```

```
;                              if not zero this byte value
;                              gives the line mask for
;                              plotting various lines
;                              (eg. 55H interpolates a line
;                              between adjacent
;                              points with every other point
;                              on the interpolation
;                              line; in other words, a fine
                               dotted line)
;
;--------------------------------------------------------


                ;..........screen memory definition

screen_memory   segment at 0B800H
even_pixels     db      8000 dup(?)     ;pixels with
                                   ;even y-coordinates
                org     2000H           ;beginning of
                                      ;high screen memory
odd_pixels      db      8000 dup(?)     ;pixels with odd
                                        ;y-coordinates
screen_memory   ends


frame   struc                       ;define structure
savebp          dw      ?           ;caller's base pointer
save_es         dw      ?           ;save es on stack for
                                    ;return to BASIC
saveret         dd      ?           ;return offset and
                                    ;segment pushed by BASIC
line_type       dw      ?           ;mask for plotting
                                    ;various line types
x_coord         dw      ?           ;x_coordinate of first
                                    ;point to be plotted
```

```
numval          dw      ?        ;number of values in
                                 ;graph_data(*) array
data_ptr        dw      ?        ;values to be graphed
                                 ;are passed in an array
                                 ;graph_data(*) pointed
                                 ;to by this pointer.
frame   ends


cseg    segment 'code'
dgroup  group   data,stack,const,heap,memory
        ;defining link to BASIC
        assume  cs:cseg,ds:dgroup,ss:dgroup
        ;BASIC defines regs
        assume  es:screen_memory        ;use extra data
                                   ;segment to access the
                                        ;screen memory

fgraph  proc    far
        public  fgraph           ;public symbols allow
                                 ;external references


        push    es               ;save BASIC's es
                                 ;register
        push    bp               ;save base pointer for
                                 ;the return to BASIC
        mov     bp,sp            ;point stack pointer at
                                 ;frame structure


                ;..........save additional registers
        push    ax               ;
        push    bx               ;
        push    cx               ;
```

```
        push    dx                  ;
        push    si                  ;
        push    di                  ;

                ;this routine assumes that the proper
                ;graphics
                ;mode has been established (eg., <SCREEN
                ;2>)

        mov     si,[bp].numval  ;get number of points
                             ;remaining to be graphed.
        mov     ax,[si]             ;
        or      ax,ax               ;if number of
                        ;repetitions is zero we're done.
        jnz     setup               ;otherwise there is work
                                    ;remaining.
        jmp     finish              ;done

                ;..........temporary storage area
                ;           (aligned on word boundary)

                even
numval_t        dw      ?           ;number of points left
                                    ;to plot
x_now           dw      ?           ;byte offset in screen
                                    ;memory for x-coordinate
last_x          dw      ?           ;last x-coord (saved for
                                    ;return to BASIC)
last_y          dw      ?           ;last y-coord (used only
                                    ;for line plots)
last_di         dw      ?           ;last screen offset
                                ;(used only for line plots)
line_mask       db      ?           ;line mask is the
                                 ;rotating buffer which is
```

```
                                          ;to generate various
                                          ;dotted/dashed lines
pixel_mask        db      ?               ;pixel mask is used to
                                          ;set one pixel in the
                                          ;screen memory (using an
                                          ;OR instruction)


setup:   mov      last_di,0ffffH          ;initialize last_di to
                                          ;ffff
         mov      numval_t,ax             ;save number of points
                                          ;to plot
         mov      si,[bp].line_type ;get line type mask
                                            ;from BASIC
         mov      ax,[si]                 ;
         mov      line_mask,al            ;and store lower byte in
                                          ;local storage

         mov      si,[bp].x_coord ;get x coordinate of
                                          ;first point from BASIC
         mov      ax,[si]                 ;
         mov      bx,numval_t             ;get number of points in
                                          ;order
         dec      bx                      ;to compute
         add      bx,ax                   ;the last x-coordinate
         cmp      bx,640                  ;x-coordinate is modulo
                                          ;640
         jle      lst_x                   ;if less than 640 store
                                          ;value
         sub      bx,640                  ;else make less than 640
lst_x:   mov      last_x,bx               ;store last_x value for
                                          ;return to BASIC

         mov      bx,seg even_pixels      ;set up screen
                                          ;memory as extra segment
         mov      es,bx                   ; (note: cannot move an
```

```
                                     ;immediate direct to es)

            mov     cl,al            ;get low byte of x_
                                     ;coordinate
            and     cl,7             ;modulo 8
            mov     pixel_mask,80H   ;initialize pixel mask
                                     ;to first bit
            jz      mask_ok          ;if x_coord mod 8 is
                                     ;zero, the mask is ok
            shr     pixel_mask,cl    ;rotate mask bit to
                                     ;correct position

    mask_ok:mov     cl,3             ;x_coord/8 is byte
                                     ;offset for pixel
            shr     ax,cl            ;this result is termed x_
                                     ;now
            mov     x_now,ax         ;

            mov     di,[bp].data_ptr
            ;use [si] with offset in bx to access y
            mov     si,[di]          ;coordinates in BASIC
                                     ;data(*) array
            mov     bx,0             ;initialize to first
                                     ;element of array
            mov     dx,[si][bx]      ;get first y-coordinate
                                     ;from BASIC
            mov     last_y,dx        ;and initialize last_y

    get_y:  mov     dx,[si][bx]      ;get y-coordinate from
                                     ;BASIC
            mov     ax,dx            ;ax is used to calculate
                                     ;screen memory offset
            shr     ax,1             ;divide by two to get
                                     ;rid of lsb
            mov     cl,80            ;80 bytes per line (lsb
                                     ;gives interlace)
```

```
          mul     cl                ;ax is offset for y-
                                    ;coord in screen memory
          add     ax,x_now          ;add offset for x-
                               ;coordinate to y offset in ax
          mov     di,ax             ;and put x,y offset into
                                    ;di
          test    dx,1              ;if y_coordinate was
                                    ;even
          jz      ln_beg            ;then we are ready to
                                    ;plot a point or a line
          add     di,2000H          ;odd pixels require the
                                    ;interlace offset

ln_beg:   cmp     last_di,0ffffH    ;if last_di is not ffff
                                    ;(first point)
          jne     lst_di            ;then go to set next
                                    ;pixel
          mov     last_di,di        ;else initialize di
                                    ;properly
lst_di:   cmp     line_mask,0       ;if line mask is not 0
          jne     draw_line         ;then draw the
                                    ;approrpiate line
set_px:   mov     al,pixel_mask     ;else set pixel using OR
                                    ;with mask
          or      even_pixels[di],al
          jmp     more              ;and go to next point


                  ;..........drawing the required line

draw_line:xchg    di,last_di        ;get old screen memory
                                    ;location to start
          mov     cx,last_y         ;cx will be the y
                                 ;distance to current pixel
          sub     cx,dx             ;dx still has current y-
                                    ;coord.
```

```
        jcxz    ln_done          ;if cx is zero then plot
                                 ;only one point
        jg      nxt_pxu          ;if last_y>y-coord then
                                 ;draw up on screen
                                 ;since lowest y is at
                                 ;top of screen


                ;..........draw a line down on screen
                ;          (increasing y)

        neg     cx               ;cx was negative
        jmp     nxt_pix          ;only plot one point per
                                 ;y-coord if possible
dn_lp:  shl     line_mask,1      ;set up line mask for
                                 ;next pixel
        jnc     nxt_pix          ;if no bits are shifted
                                 ;out then no pixel here
        or      line_mask,1      ;is msb was shifted out,
                                 ;now set lsb
        mov     al,pixel_mask    ;load pixel mask and
        or      even_pixels[di],al      ;set pixel using
                                        ;OR with mask

                ;..........now find next pixel position
                ;          for line
nxt_pix:xor     di,2000H         ;change from high to low
                                 ;memory (or vice versa)
        test    di,2000H         ;if in high screen
                                 ;memory
        jnz     dn_di            ;then di points to next
                                 ;pixel
        add     di,80            ;else go to next line in
                                 ;lower memory
dn_di:  loop    dn_lp            ;do another pixel in
                                 ;this line
```

```
        jmp     ln_done         ;plot last pixel when
                                ;done

                ;..........draw a line up on screen
                ;          (decreasing y)

up_lp:  shl     line_mask,1     ;set up line mask for
                                ;next pixel
        jnc     nxt_pxu         ;if no bits are shifted
                                ;out then no pixel here
        or      line_mask,1     ;is msb was shifted out,
                                ;now set lsb
        mov     al,pixel_mask   ;load pixel mask and
        or      even_pixels[di],al      ;set pixel using
                                        ;OR with mask

                ;..........now find next pixel position
                ;          for line
nxt_pxu:xor     di,2000H        ;change from high to low
                                ;memory (or vice versa)
        test    di,2000H        ;if in low screen memory
        jz      up_di           ;then di points to next
                                ;pixel
        sub     di,80           ;else go to next line in
                                ;upper memory
up_di:  loop    up_lp           ;do another pixel in
                                ;this line
;       jmp     ln_done         ;plot last pixel when
                              ;done(statement not needed
;                              here)


                ;..........finish up with line by
                ;          storing current data
```

```
ln_done:shl   line_mask,1        ;set up line mask for
                                 ;next pixel
        jnc   end_pix            ;if no bits are shifted
                                 ;out then no pixel here
        or    line_mask,1        ;is msb was shifted out,
                                 ;now set lsb
        mov   al,pixel_mask      ;load pixel mask and
        or    even_pixels[di],al        ;set pixel using
                                        ;OR with mask
end_pix:mov   last_y,dx          ;save present y-
                                 ;coordinate
              mov    last_di,di         ;save present
                                     ;pixel byte pointer


              ;..........prepare for next point if
              ;          there is one

more:   dec   numval_t           ;one less point left now
        jz    finish             ;finished if none left
        inc   bx                 ;if not done increment
                                ;base index by 2 to point
        inc   bx                 ;to next y-coord in
                                 ;BASIC array
        shr   pixel_mask,1       ;move pixel mask to next
                                 ;x-coord
        jnz   go_gety            ;if mask points to some
                                 ;pixel get the y-coord
        mov   pixel_mask,80H     ;otherwise set up mask
                                ;for next 8 x-coordinates
        inc   x_now              ;x_now points to next
                                 ;byte (for next 8 pts)
        inc   last_di            ;fix last di to point to
                                 ;present column
        cmp   x_now,80           ;there are only 80 bytes
                                 ;per line, so
```

```
          jl      go_gety           ;if x_now<80 then x_now
                                    ;is ok to get next y
          mov     x_now,0           ;otherwise wrap around
                                    ;to x_now=0
          sub     last_di,80        ;also reset di to first
                                    ;column
go_gety:jmp       get_y             ;


                  ;..........finish up and send present
                  ;               pointers,mask to BASIC

finish: mov       al,line_mask      ;get present line mask
        xor       ah,ah             ;zero upper byte
        mov       si,[bp].line_type ;and
        mov       [si],ax           ;send to BASIC
        mov       ax,last_x         ;get last x-coordinate
        mov       si,[bp].x_coord   ;and send to BASIC
        mov       [si],ax           ;


                  ;..........restore all registers which
                  ;               were corrupted
        pop       di                ;
        pop       si                ;
        pop       dx                ;
        pop       cx                ;
        pop       bx                ;
        pop       ax                ;


        pop       es                ;restore the es register
                                    ;and
        pop       bp                ;restore BASIC base
                                    ;pointer before returning
        ret       8                 ;delete 4 parameter
```

```
                                    ;addresses (8 bytes) from
                                    ;stack and return to
                                    ;calling routine
fgraph  endp
cseg    ends
        end
```

APPENDIX C

```
' CALIB - program to calibrate instruments using
'   board#1
' last revision:  1985

defint a-y
' only z denotes a real number
dim buffer(12800)
hrbpm=0
zfqlow=0.
zfqres=0.
zlfa=0.
zrfa=0.
cls

'define ports on 8253
timer0=&h704
timer1=&h705
timer2=&h706
con8253=&h707

' set timer modes to 16 bit square wave rate
'   generators
out con8253,&h36
out con8253,&h76
out con8253,&hB6

'for testing set timer 0 to 100Hz timebase
out timer1,164
```

```
out timer1,3

out timer2,0
'set timer 0 to 1280Hz timebase
out timer2,5
' (2.38MHz/1864) (1864=2*256+104)
                                'set timer 2 as a 1Hz
                                '  clock at
                                'startup
hrbpm=60                        '(gives a heart rate
                                '  signal at
                                '60bpm)
out timer0,1                    'set timer 0 as a flip
                                '  flop
out timer0,0                    '


' turn the gates on using the 8255 at bits 0,1,2
'   on portc
porta=&H70C
portb=&H70D
portc=&H71E
con8255=&H71F
' port A output port B input port C output
' first set all 8255 ports to output, then set
'   portc to
' 0FFH
out con8255,130
out portc,&H0FF


' first print out the present value of the
'   interrupt
' vectors
locate 4,1
```

```
        gosub 10000


        ' install the interrupt with a dummy buffer and
        '   print
        ' vectors
        reseter=256
        call wrbuffer(reseter)
        reseter=128
        call wrbuffer(reseter)
        call instint
        locate 5,1
        gosub 10000


        ' now go through required startup subroutines
        gosub 90
        ' set up breathing signal
        gosub 70
        ' set up heart rate variations
        gosub 50
        ' put some information on screen
        gosub 80                   ' turn D/A on
        locate 1,1
        print "commands: h(rvar),i(nt
               on),q(uit),r(beats),b(reath),c(ounts)"


        ' wait until user hits a key
        savekey$=""
40      while
len(savekey$)=0:savekey$=savekey$+inkey$:wend
        if savekey$="r" then gosub 50
        'print heart beats
        if savekey$="q" then goto 9996  'quit
        if savekey$="c" then gosub 60   'print timers
```

```
        if savekey$="h" then gosub 70
        'set up heart rate variations unmask interrupts
        if savekey$="i" then gosub 80
        if savekey$="b" then gosub 90
        'set up breathing signal
        savekey$=""
        goto 40

        'print present value of heartbeats

50      locate 7,1
        call rdbeat(n)
        print "present heart beats are: ";n;time$
        return


        ' print present value of counters
60      out control,0            'latch timer0
        tlow0=inp(timer0)
        thigh0=inp(timer0)
        out control,&h40         'latch timer1
        tlow1=inp(timer1)
        thigh1=inp(timer1)
        out control,&h80         'latch timer2
        tlow2=inp(timer2)
        thigh2=inp(timer2)
        locate 8,1
        print "timer0:
";tlow0+thigh0*16;tab(20);"            timer1:
              ";tlow1+thigh1*16;
        print tab(40);"timer2: ";tlow2+thigh2*16
        return



        ' set up the heart rate variations
```

```
'       respiratory frequency is given by
'         1280Hz/buffer
'        length
'       low frequency is 1280Hz/low frequency
'         divider
'
70      if numval<=0 then beep:print "setup analog
            buffer first":return
71      locate 17,1
        print "present lfa,rfa(bpm)= ";zlfa,zrfa,"at
freqs(Hz):";zfqlow,zfqres
        input "lfa,rfa,low freq: ",zlfan,zrfan,zfqlown
        if zlfan>30. then beep:goto 71 else zlfa=zlfan
        if zrfan>30. then beep:goto 71 else zrfa=zrfan
        if zfqlown<.02 or zfrlown>zfqres then beep:goto
71 else
           zfqlow=zfqlown
        locate 21,1
        print "mean heart rate(bpm)= ";hrbpm
72      locate 22,1
        input "new mean heart rate(bpm): ",newhrbpm
        if newhrbpm>150 or newhrbpm<30 then beep:goto 72
else
           hrbpm=newhrbpm
                'clear screen after input
        locate 17,1
        print space$(72)
        print space$(72)
        print space$(72)
        print space$(72)
        print space$(72)


        ' now compute values for hrsetup subroutine
        meandiv=76800#/hrbpm    '1280*60 ticks/min gives
                                '    ticks/beat
```

```
        rfascal=76800#/(hrbpm-zrfa)-76800#/(hrbpm+zrfa)
                            ' rfascal is the total excursion
                            '     of respiration
        lfascal=76800#/(hrbpm-zlfa)-76800#/(hrbpm+zlfa)
                            ' lfascal is the total excursion
                            '   of low frequency
        lowdiv=meandiv-(rfascal+lfascal)/2#

        tbaserst=1280#/zfqlow
        locate 17,1
        print "tbaserst,rfascal,lfascal,lowdiv:
              ";tbaserst;rfascal;lfascal;
        print lowdiv
        call hrsetup(tbaserst,rfascal,lfascal,lowdiv)

        return



        ' print out interrupt controller parameters
80      locate 10,1
        mask=inp(&h21)
        mask=maskx or 24
        out &h21,mask
        mask=inp(&h21)
        print "8259 IMR(interrupt mask regsiter)=
";mask;"
            =";hex$(mask)
        return



        ' this subroutine will change the analog buffer
90      locate 12,1
        input "enter breathing rate (bpm): ",brate
        if brate>75 or brate<7 then beep:goto 90
```

```
            zfqres=brate/60#
            numval=76800#/brate
            ztincr=8*ATN(1#)/numval
            locate 12,40
            color 31:print "calculating respiratory
signal...":color
              7
            call exstint              ' turn off interrupts
                                       '    while
                  resetting buffer
            reseter=256
            call wrbuffer(reseter)
            for itime=0 to numval
                ztnow=ztnow+ztincr
                analogval=127*(1#+SIN(ztnow))
                call wrbuffer(analogval)
            next itime
            call instint
            locate 12,40
            print "respiratory signal active now      "
            return


            ' exstall the interrupt and print vector
9996        cls
            locate 4,1
            gosub 10000
            call exstint
            locate 5,1
            gosub 10000
            locate 21,1
9999        stop


            ' subroutine to print out the interrupt vectors
```

```
10000   def seg=0
        print "IRQ3 @0B*4H: ";hex$(peek(&h2C));"
              ";hex$(peek(&h2D));" ";
        print hex$(peek(&h2E));"
";hex$(peek(&h2F));tab(40);
        print "IRQ4 @0C*4H: ";hex$(peek(&h30));"
              ";hex$(peek(&h31));" ";
        print hex$(peek(&h32));" ";hex$(peek(&h33))
        return

        end
```

```
                page    66,80
; bdzint.asm - an assembler routine to handle interrupts
;               from IRQ3
; Last revision:  1 April 1985
;
;
                ;------------------------------;
                ;  8088 interrupt location      ;
                ;------------------------------;

abs0            segment at 0    ;absolute memory segment
                                ;allows placement of
                                ;interrupt address
                                ;future timebase
                                ;  interrupt handler
                                ;  resides at int 0B
IRQ3_int        dw      2 dup(?);offset value is a word

                org     0CH*4   ;heart beat interrupt
                                ;handler resides at int
                                ; 0C
IRQ4_int        dw      2 dup(?);offset value is a word

abs0            ends            ;



                ;------------------------------;
                ; int_buffer: area to save DOS  ;
                ;      dummy interrupt ptr      ;
                ;------------------------------;


int_buffer      segment         ;data segment containing
                                ;user interrupt buffer
save_int        dw      4 dup(?);offset for two DOS
```

```
                                                ;interrupts saved
                                                ;to be restored using
                                                ;exstint

int_buffer      ends                            ;



                ;--------------------------;
                ; working storage for      ;
                ; time base interrupts     ;
                ;--------------------------;


dseg_tbase    segment           ;data segment for timebase
                                ; interrupt
heartbeats    dw          ?     ;keep track of heart beats
                                ; here (for debugging)
base_rate     dw          ?     ;lowest divisor for heart
                                ; rate
lfa_scal      db          ?     ;low frequency modulation
rfa_scal      db          ?     ;high frequency modulation
tbase_ctr     dw          ?     ;counter for timebase
                                ; interrupt
                                ;(use for low frequency
                                ;  generation)
tbase_rst     dw          ?     ;reset value for tbase_ctr
                                ; used to set low frequency
tbase_ptr     dw          ?     ;pointer to present analog
                                ; value
tbase_len     dw          ?     ;length of analog data buffer
tbase_buffer db  2800dup(?)  ;buffer for A/D values
dseg_tbase    ends              ;
```

```
                  ;------------------------------------;
                  ; setup structures to allow access to;
                  ; arguments pased by BASIC           ;
                  ;------------------------------------;


                  ; subroutine rdbeat(BASIC_beats)
frame_rd          struc              ;define the stack
                                   ;structure for passing
                                     ;arguments to BASIC
savebpl           dw      ?          ;caller's base pointer
saveretl          dd      ?          ;return offset and
                                     ;segment pushed by BASIC
BASIC_beats       dw      ?          ;place to return heart
                                     ;beats to BASIC
frame_rd          ends

                  ;subroutine wrbuffer (analog)
frame_wr     struc       ;define the stack structure
                         ;   for passing
                         ;arguments from BASIC to
                         ;   analog buffer
savebp2      dw     ?    ;caller's base pointer
saveret2     dd     ?    ;return offset and segment
                         ;  pushed by BASIC
analog       dw     ?    ;place to receive analog value
                         ;  from BASIC
frame_wr     ends

                         ;subroutine hrsetup(B_lreset,
                         ;   Brfa_scal,Blfa_scal,Bbase_
                         ;   rate)
frame_hr     struc       ;define the stack structure for
                         ;   passing
                         ;arguments from BASIC to heart
                         ;  rate controls
```

```
savebp3     dw    ?    ;caller's base pointer
saveret3    dd    ?    ;return offset and segment pushed
                       ;   by BASIC
Bbase_rate dw     ?    ;BASIC's lowest divider for heart
                       ;  rate
Blfa_scal   dw    ?    ;BASIC's low frequency scaler
                       ;  (amplitude)
Brfa_scal   dw    ?    ;BASIC's high frequency scaler
                       ;  (amplitude)
B_lreset    dw    ?    ;BASIC's low frequency timer
                       ;  reset value
frame_hr    ends

                  ;..........code segment begins here

cseg_calibs        segment 'code'
basic_dgroup      group   data,stack,const,heap,memory
                                   ;defining link to BASIC
porta             equ     0700H   ;port definitions for
                                  ;8255 port expander
portb             equ     0708H   ;these addresses are
                                  ;decoded on the homemade
portc             equ     0710H   ;board
control           equ     0718H   ;control word in the
                                  ;8255
timer0            equ     0720H   ;8253 timer0 register
timer1            equ     0721H   ;8253 timer1 register
timer2            equ     0722H   ;8253 timer2 register
con8253           equ     0723H   ;8253 control register


           ;-------------------------------------------;
           ; timebase interrupt handler (not accessible to;
           ; BASIC)                                     ;
           ;-------------------------------------------;
                  ;this routine reads the A/D every timer0
```

```
                ;tick
                ;with the next point in the analog
                ;buffer

tbase_int       proc    far     ;this procedure is not
                                ;made public
                assume  cs:cseg_sync,ds:dseg_
                   base,es:nothing,ss:nothing
                push    ax      ;save registers used
                                ;during interrupt
                push    bx      ;
                push    dx      ;
                push    ds      ;

                mov     ax,dseg_base    ;set up segment
                                 ;register for data area
                mov     ds,ax           ;


                ;..........increment counter used for
                            ;low frequency generation
                dec   tbase_ctr   ;decrement
                                  ; interrupt counter
               jnz   ctr_ok       ;if not zero then
                                  ;  continue
               mov   ax,tbase_rst ;else reload reset
                                  ;value
               mov   tbase_ctr,ax ;
               ctr_ok:
               ;..........get analog value from
               ;buffer and send to DAC


               mov   bx,tbase_ptr ;get pointer to
```

```
                              ;analog data
        dec   bx              ;
        mov   al,tbase_buffer[bx]  ;get analog
                              ;         value

        mov   dx,porta        ;send analog value
                              ;to DAC
        out   dx,al              ;

        mov   dx,control      ;toggle the write
                              ;latch for the DAC
        mov   al,6            ;by using direct bit
                              ;reset
        out   dx,al              ;and
        inc   al                 ;reset commands
        out   dx,al              ;

        dec   tbase_ptr       ;point to next
                              ;value
        jnz   tbase_eoi       ;if zero, reset
                              ;pointer
        mov   ax,tbase_len       ;reset with buffer
                              ;length
        mov   tbase_ptr,ax       ;

         ;..........acknowledge interrupt to
         ;          8259A
tbase_eoi:   mov     al,20H   ;send EOI to 8259A
             out     20H,al   ;

             pop     ds       ;restore registers which
                              ;were used
             pop     dx       ;
             pop     bx       ;
             pop     ax       ;
             iret             ;return to place where
```

```
                                        ;interrupt occurred

debugmsgl       db      'this is the end of the time
                         base interrupt'

tbase_int       endp


                ;-----------------------------------------;
                ; heart beat interrupt handler (not accessible ;
                ; to BASIC)                                ;
                ;-----------------------------------------;

                ;this routine updates the timerl rate generator
                ;every heart beat with the divider necessary to
                ;generate the next heart beat
                ;
                ;the respiratory modulation is given by a scaler
                ;   (0-255)
                ;times the present value of the respiratory
                ;   signal.
                ;the low frequency modulation is given by scaler
                ;    (0-255)
                ;times a value selected from the respiratory
                ;    buffer.
                ;the value selected is the
                ;    (tbase_ctr/tbase_rst)*buffer_length
                ;element

hbeat_int       proc    far     ;this procedure is not
                                ;made public
                assume  cs:cseg_calibs,ds:dseg_tbase
                assume  es:nothing,ss:nothing
```

```
push    ax          ;save registers during
                    ;interrupt
push    bx          ;
push    cx          ;
push    dx          ;
push    ds          ;

mov     ax,dseg_tbase     ;set up segment
                    ;register for data area
mov     ds,ax             ;

inc     heartbeats        ;increment heart
                          ;   beat counter

;........calculate low frequency
;             modulation
; (the tbase buffer is used as a trig
;  table here)
mov     ax,tbase_ctr      ;get number of
                          ;1280Hz pulses
dec     ax                ;
mul     tbase_len         ;scale by length
                          ;of respiratory
                          ;  buffer
div     tbase_rst         ;divided by reset
                          ;value to get
                          ;   pointer
mov     bx,ax             ;to low frequency
                          ; modulation
mov     al,tbase_buffer[bx]    ;get
                          ; sinusoidal
                          ; modulation
mul     lfa_scal          ;and scale
                          ; appropriately
mov     cx,ax             ;cx accumulate
                          ;divider for
```

```
                                    ; 1280Hz clock

            ;........calculate respiratory
            ;            modulation
            mov     bx,tbase_ptr      ;get present
                                      ;respiration
                                      ;signal
            mov     al,tbase_buffer[bx]    ;from
                                      ;buffer
            mul     rfa_scal          ;scale with rfa
                                      ;scaler
            add     cx,ax             ;and add to cx

            add     cx,base_rate      ;finally add base
                                      ;rate to get
                                      ;  value for
                                      ;timer1 (heart
                                      ;rate
  generator                                     ;  on
                                      ;   8253)

            ;.............. send new divider to 8253
            ;     timer
            mov     al,76H            ;set timer 1 to
                                      ;square wave
                                      ;  generator
            mov     dx,con8253        ;
            out     dx,al             ;

            mov     dx,timer1         ;send divider to
                                      ;time1
            mov     al,cl             ;low byte first
            out     dx,al             ;
            mov     al,ch             ;high byte next
            out     dx,al             ;
```

```
          ;..........acknowledge interrupt to
          ;          8259A
          mov     al,20H  ;send EOI to 8259A
          out     20H,al  ;

          pop     ds      ;restore registers and
          pop     dx      ;
          pop     cx      ;
          pop     bx      ;
          pop     ax      ;
          iret            ;return to place where
                          ;interrupt occurred


debugmsg2      db      'this is the end of the heart
                        beat interrupt'

hbeat_int      endp



      ;--------------------------------------------;
      ; subroutine instint (install_interrupts)    ;
      ;--------------------------------------------;

instint        proc    far
               public  instint
              ;public symbol allows external references
              ;es,ds used to access interrupt and must
              ;  be restored movsw
              ;uses (ds:si)(es:di) addr
               assume  cs:cseg_calibs,ss:basic_
                   dgroup,ds:basic_dgroup
               assume  es:int_buffer

               ;..........save registers
```

```
push   ds          ;save ds register on the
                   ;  stack
push   es          ;save es register on the
                   ;  stack

push   bp          ;save BASIC base pointer
                   ;    for return to BASIC
mov    bp,sp       ;point stack pointer at
                   ;frame reference to
                   ;address of BASIC analog
                   ;data buffer

push   ax          ;save additional
                   ;registers
push   si          ;
push   di          ;

;set up the segment registers as assumed

mov    ax,int_buffer     ;
;es points to buffer area to save
;DOS dummy interrupt vector
mov    es,ax             ;
mov    ax,0              ;ds points to
                   ;abs0 (interrupt table)
mov    ds,ax             ;
assume ds:abs0           ;

      ;setup access to interrupt vectors
lea    di,save_int       ;load offset of
                        ;save_int in es,di
lea    si,IRQ3_int       ;load offset of
                        ;IRQ3_int in ds,si
movsw                    ;save DOS dummy
                   ;interrupt vectors to be
movsw                    ;restored later
```

```
                movsw                   ;now saving IRQ4
                movsw                   ;

;install the DAC timebase (IRQ3)
                mov     IRQ3_int+2,cseg_calibs
                mov     IRQ3_int,offset tbase_int;
                        ;interrupt handler now
;install the heart beat (IRQ4) interrupt handler now
                mov     IRQ4_int+2,cseg_calibs;
                mov     IRQ4_int,offset hbeat_int;


                ;..........return to BASIC

                pop     di      ;restore additional
                                 registers
                pop     si      ;
                pop     ax      ;

                pop     bp      ;restore BASIC's base
                                ;pointer and
                pop     es      ;segment registers
                                  before returning
                pop     ds      ;
                ret     0       ;delete 0 parameters (0
                                ;bytes) from the stack
                                ;and return to the
                                ;calling routine

debugmsg3       db      'this is the end of the
                        interrupt installation'


instint         endp
```

```
;--------------------------------------;
; subroutine exstint (exstall_         ;
; interrupts)                          ;
;--------------------------------------;

exstint         proc    far
                public  exstint ;public symbol allows
                                   ;external references
                assume  cs:cseg_calibs,ss:basic_dgroup
                assume  ds:int_buffer,es:abs0
                ;es,ds used to access interrupt
                ;vectors and must be restored
                ;movsw uses (ds:si)(es:di) addr

                ;..........save registers

                push    ds      ;save ds register on the
                                ;  stack
                push    es      ;save es register on the
                                ;  stack
                push    bp      ;save BASIC base pointer
                                ;    for return to BASIC
                mov     bp,sp   ;point stack pointer at
                                ;     frame reference to
                                ;access arguments passed
                                ;   by BASIC (none here)

                push    ax      ;save additional
                                ;registers
                push    si      ;
                push    di      ;
                                ;set up the segment
                                ;  registers as assumed
```

```
        mov     ax,0                ;es points to
                            ;abs0 (interrupt table)
        mov     es,ax               ;
        mov     ax,int_buffer       ;ds points to
                            ;buffer area to save
        mov     ds,ax               ;DOS dummy
                            ;interrupt vector

                ;setup access to interrupt vectors
        lea     di,IRQ3_int         ;load offset of
                                ;IRQ3_int in es,di
        lea     si,save_int         ;load offset of
                                ;save_int in ds,si
        movsw                       ;restore DOS
                            ;dummy interrupt vectors
        movsw                       ;for IRQ3
        movsw                       ;and IRQ4
        movsw                       ;


;..........return to BASIC

        pop     di          ;restore additional
                               registers
        pop     si          ;
        pop     ax          ;

        pop     bp          ;restore BASIC's base
        pop     es          ;pointer and segment
        pop     ds          ;registers before
                            ;returning
        ret     0           ;delete 0 parameters (0
                            ;bytes) from the stack
                            ;and return to the
                            ;calling routine
```

```
debugmsg4       db      'this is the end of the
                         interrupt exstallation'

exstint         endp



                ;---------------------------------------;
                ; subroutine rdbeat (read_heart_beats   ;
                ;---------------------------------------;

rdbeat          proc    far
                public rdbeat   ;public symbol allows
                                ;external references
                assume cs:cseg_calibs,es:dseg_tbase
                assume ds:basic_dgroup,ss:basic_dgroup


                ;..........save registers

                push    bp      ;save BASIC base pointer
                                ;for return to BASIC
                mov     bp,sp   ;point stack pointer at
                                ;frame reference to
                                ;access arguments passed
                                ;by BASIC (one here)

                push    ax      ;save additional
                                ;registers
                push    es      ;
                push    di      ;

                mov     ax,dseg_tbase   ;set up segment
```

```
                                ;register for data area
            mov     es,ax              ;

            mov     ax,heartbeats            ;get
                              ;beats from local memory
            mov     di,[bp].BASIC_beats      ;
            mov     [di],ax                  ;send
                                     ;beats to BASIC

            ;..........return to BASIC

            pop     di          ;restore additional
                                 registers
            pop     es          ;
            pop     ax          ;

            pop     bp          ;restore BASIC's base
                                ;pointer,
            ret     2           ;delete 2 parameters (4
                                ;bytes) from the stack
                                ;and return to the
                                ;calling routine

debugmsg5   db      'this is the end of the heart
                     beat read routine'

rdbeat  endp

            ;---------------------------------------;
            ; subroutine wrbuffer(analog)           ;
            ;---------------------------------------;

wrbuffer    proc    far
```

```
public wrbuffer   ;public symbol allows
                  ;external references
assume cs:cseg_calibs,es:dseg_tbase
assume ds:basic_dgroup,ss:basic_dgroup


;..........save registers

push    bp        ;save BASIC base pointer
                  ;for return to BASIC
mov     bp,sp     ;point stack pointer at
                  ;frame reference to
                  ;access arguments passed
                  ;by BASIC (one here)

push    ax        ;save additional
                  ;registers
push    bx        ;
push    es        ;
push    si        ;
mov     ax,dseg_tbase    ;set up segment
                   ;register for data area
mov     es,ax            ;

mov   si,[bp].analog   ;get analog value
                       ;from BASIC
mov   ax,[si]          ;
test  ah,OFFH          ;if upper byte is
                       ;zero
jz    new_buff         ;then install a
                       ;new point in the
                       ;buffer
mov   tbase_len,0      ;otherwise reset
                       ;the buffer
mov   tbase_ptr,1      ;
jmp   wr_ret           ;
```

```
            mov   bx,tbase_len          ;get present
                                        ;pointer and use
                                        ;it
            mov   tbase_buffer[bx],al    ;to store
                                        ;buffer value
            inc   tbase_len             ;point to next
                                        ;buffer value


            ;..........return to BASIC

            pop      si        ;restore additional
                               ;registers
wr_ret:     pop      es        ;wr_ret:
            pop      bx        ;
            pop      ax        ;

            pop      bp        ;restore BASIC's base
                               ;pointer,
            ret      2         ;delete 1 parameters (2
                               ;bytes) from the stack
                               ;and return to the
                               ;calling routine

debugmsg6       db      'this is the end of the buffer
                         write routine'

wrbuffer        endp


;-------------------------------------------------------;
; subroutine hrsetup(B_1reset,Brfa_scal,Blfa_scal,      ;
; Bbase_rate)                                           ;
;-------------------------------------------------------;
```

```
proc    far
public hrsetup    ;public symbol allows
                    external references
assume cs:cseg_calibs,es:dseg_tbase
assume ds:basic_dgroup,ss:basic_dgroup


;............save registers

push   bp          ;save BASIC base
                   ;pointer for return
                   ;to BASIC
mov    bp,sp       ;point stack pointer
                   ;at frame
                   ;reference to
                   ;access arguments
                   ;passed by BASIC
                   ;(one here)

push   ax          ;save additional
                   ;registers
push   es          ;
push   si          ;

mov   ax,dseg_tbase    ;set up segment
                       ;register for
                   ;data area
mov   es,ax        ;

mov   si,[bp].Bbase_rate  ;get lowest
                   ;divisor for heart
mov  ax,[si]       ;rate from BASIC
mov   base_rate,ax    ;and save in local
                   ;       data
                   ;    segment
```

```
        mov     si,[bp],Blfa_sacl   ;get low freq
                               ;         modulation
                               ;         scale
        mov     ax,[si]        ;         from BASIC
        mov     lfa_scal,al ;and save LSbyte in
                               ;local data
                               ;   segment

        mov     si,[bp].Brfa_scal  ;get high freq
                               ;      modulation scale
        mov     ax,[si]        ;from BASIC
        mov     rfa_scal,al          ;and save
                               ;LSbyte in local data
                               ;segment
        mov     si,[bp].B_lreset   ;get low freq
                               ;   timer reset value
        mov     ax,[si]        ;from BASIC
        mov     tbase_rst,ax         ;and save in
                               ;  local data segment

;..........return to BASIC

        pop     si             ;restore additional
                               ;registers
        pop     es          ;
        pop     ax          ;

        pop     bp          ;restore BASIC's base
                            ;pointer,
        ret     8           ;delete 4 parameters (8
                            ;  bytes) from the stack
                            ;and return to the
                            ;  calling routine

debugmsg 7      db    'this is the end of the heart rate
                       setup routine'
```

```
hrsetup        endp

cseg_calibs    ends

               end
```

WHAT IS CLAIMED IS:

1. An apparatus for correcting artifacts in a series of heartbeats comprising:

means for collecting a series of heartbeat samples;

means coupled to said means for collecting, for selecting an appropriate interval between heartbeats;

means for identifying a mean variance among the intervals between heartbeat samples coupled to said means for determining;

means, coupled to said means for identifying, for establishing an acceptable range of slewing rates as a function of the mean variance;

means, coupled to said means for determining, for particularizing the absolute value of the slewing rate of a heartbeat sample relative to the mean interval; and

means, coupled to said means for particularizing, for substituting the appropriate interval between heartbeats for all heartbeat interval samples having an absolute value outside the range of acceptable slewing rates.

2. The apparatus as recited in claim 1 wherein said means for selecting an appropriate interval comprises means for dividing intervals having a length equal to a multiple of the appropriate interval by the multiple.

3. The apparatus as recited in claim 1 wherein said means for selecting an appropriate interval comprises means for discarding interval shorter than a predetermined length.

4. The apparatus as recited in claim 1 wherein said means for selecting an appropriate interval comprises means for determining a mean interval and means for substituting a mean interval for intervals having preceded by a preselected numberof intervals having an absolute value outside the range of acceptable slewing rates and having an absolute value outside of the range of acceptable slewing rates.

5. A method for correcting artifacts in a series of heartbeats comprising the steps of:

collecting a series of heartbeat samples;

selecting an appropriate interval between heartbeats;

identifying variances in the intervals between heartbeats;

establishing an acceptable range of slewing rates as a function of a mean variance;

particularizing the absolute value of the slewing rate of a heartbeat sample relative to the mean interval; and

substituting the selected interval for all heartbeat interval samples having an absolute value outside the range of acceptable slewing rates.

6. The method as recited in claim 5 wherein said selecting step comprises the step of dividing intervals having a length equal to a multiple of the appropriate interval by the multiple.

7. The method as recited in claim 5 wherein said selecting step comprises the steps of determining a mean interval and substituting a mean interval for intervals having preceded by a preselected number of intervals having an absolute value outside the range of acceptable slewing rates and having an absolute value outside of the range of acceptable slewing rates.

8. The method as reicted in claim 5 wherein said selecting step comprises the step of discarding interval shorter than a predetermined length.

9. Apparatus for calibrating a heart rate power spectrum monitor comprising:

means for supplying a signal simulating a heart rate;

means for generating a signal simulating a respiratory frequency fluctuation in heart rate;

means for providing a signal simulating a low frequency fluctuation in heart rate; and

means for applying signals from said means for supplying, said means for generating and said means for providing to a power spectrum monitor.

10. Apparatus for heart rate fluctuation power spectral analysis comprising:

means for providing an electrocardiogram signal;

means for supplying an electroplethysmogram signal;

means, coupled to said means for providing and to said means for supplying, for obtaining a heart rate fluctuation power spectrum from an electrocardiogram signal and an electroplethysmogram signal; and

relative means, coupled to said means for obtaining, for displaying a heart rate fluctuation power spectrum.

11. Apparatus for trending heart rate fluctuation power spectral data comprising:

means for providing an electrocardiogram signal;

means for supplying an electroplethysmogram signal;

means, coupled to said means for providing and to said means for supplying, for obtaining a heart rate fluctuation power spectrum from an electrocardiogram signal and from an electropleythyswogram signal; and

means, coupled to said means for obtaining, for storing heart rate fluctuation power spectral data;

addressable means, coupled to said means for storing, for transmitting stored heart rate fluctuation power spectral data;

means, coupled to said addressable means for transmitting, for converting heart rate fluctuation power spectral data into graphic form; and

real time means, coupled to said means for converting, for displaying heart rate fluctuation power spectra.

12. The apparatus according to claim 11 further comprising:

means, coupled between said means for obtaining and said means for storing, for segmenting data into overlapping samples.

13. A method for treatment of a condition related to malfunctions of the cardiovascular control system in a patient comprising the steps of:

monitoring a power spectrum of heart rate fluctuations in the patient;

identifying a level below about 0.1 $(\text{beats/min.})^2$ in the power spectrum of heart rate fluctuations at a frequency between about 0.04 and about 0.10 Hz as indicative of cardiovascular instability; and

applying a procedure to treat the condition and thereby to increase the level of heart rate fluctuations between about 0.04 and about 0.10 Hz.

14. A method for treatment of a condition related to malfunctions of the cardiovascular control system in a patient comprising the steps of:

monitoring a power spectrum of heart rate fluctuations in the patient; and

identifying a marked increase to above about 10 $(\text{beats/min.})^2$ in heart rate fluctuations at a frequency between about 0.04 to about 0.10 Hz as indicative of cardiovascular stress; and

applying a procedure to treat the condition and thereby to decrease the level of heart rate fluctuations between about 0.04 and about 0.10 Hz.

15. A method for treatment of a condition related to cardiovascular control system in a patient comprising the steps of:

monitoring a power spectrum of heart rate fluctuations in the patient; and

identifying a ratio of the area under a heart rate fluctuation power spectrum of a peak at a frequency between about 0.04 and about 0.1 Hz to the area under a peak in the heart rate fluctuation power spectrum centered at the mean respiratory rate about 0.1 Hz as having an absolute value less than 2.0 as indicative of cardiac instability; and

applying a procedure to treat the condition and thereby to increase the ratio.

16. A method for treatment of a condition related to cardiovascular control system in a patient comprising the steps of:

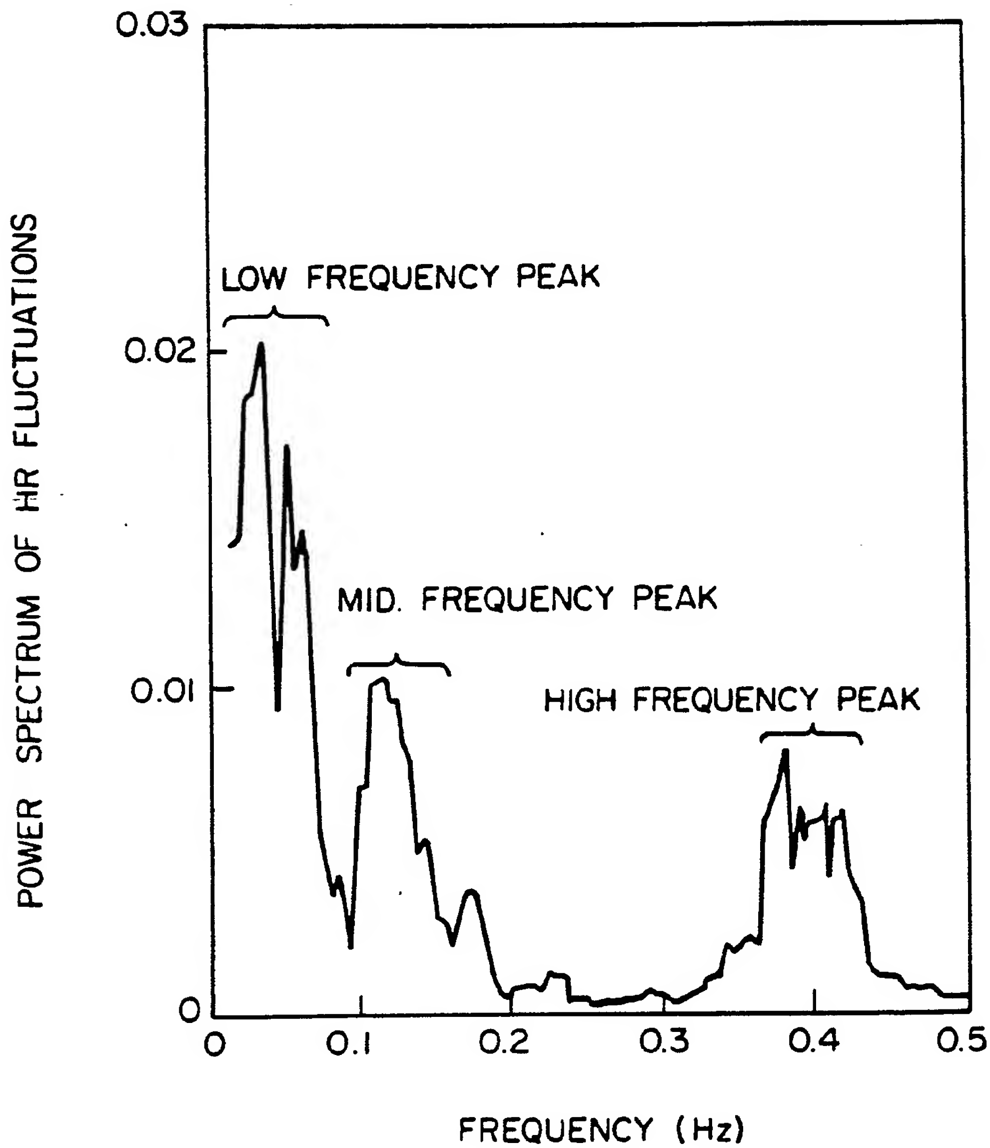
monitoring a power spectrum of heart rate fluctuations in the patient; and

identifying a ratio of the area under a heart rate fluctuation power spectrum of a peak at afrequency between about 0.04 and about 0.1 Hz to the area under a peak in the heart rate fluctuation power spectrum centered at the mean respiratory rate about 0.1 Hz as having an absolute value greater than or about 50 as indicative of cardiac instability; and

applying a procedure to treat the condition and thereby to increase the ratio.

FIG. 1

PRIOR ART



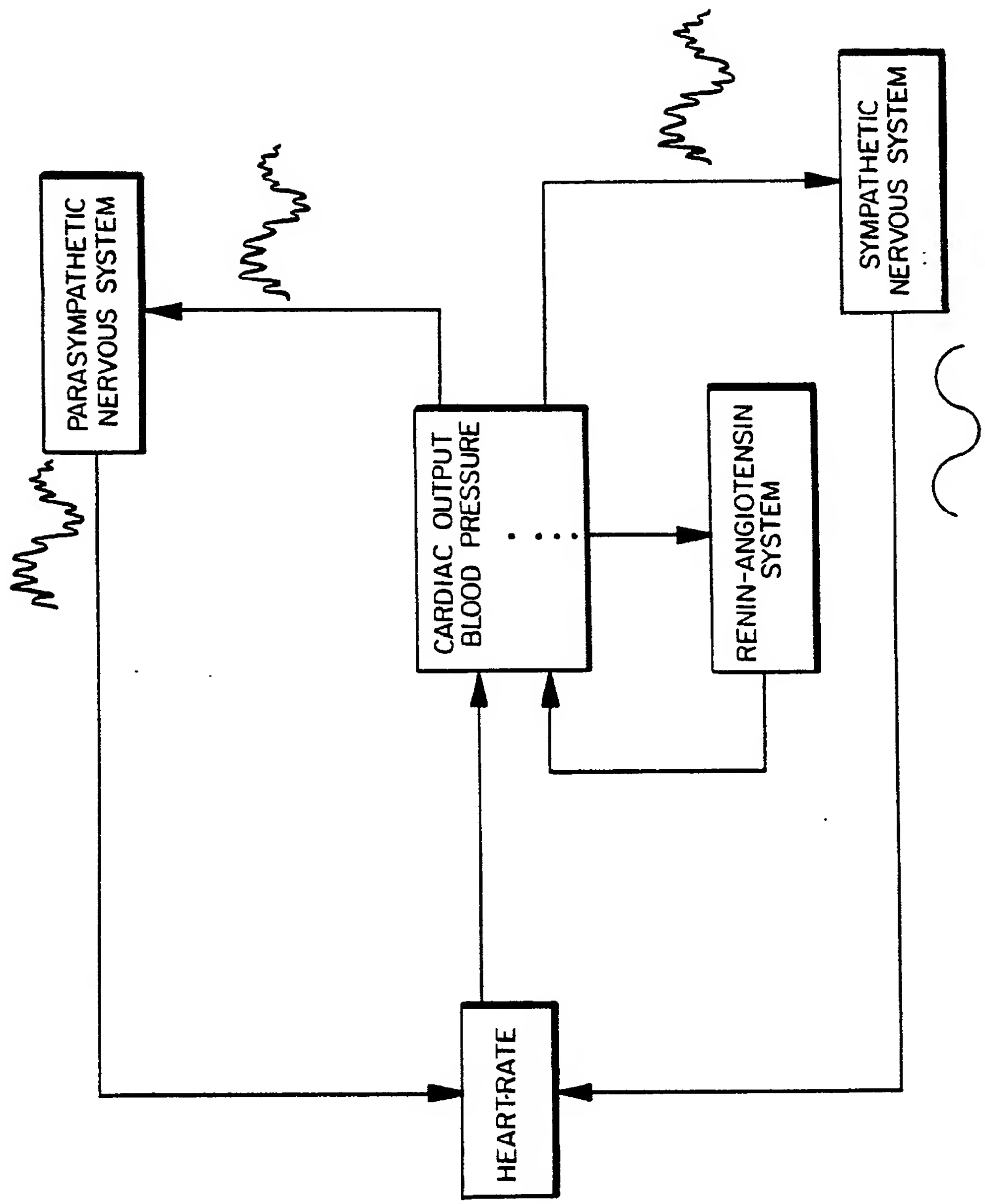
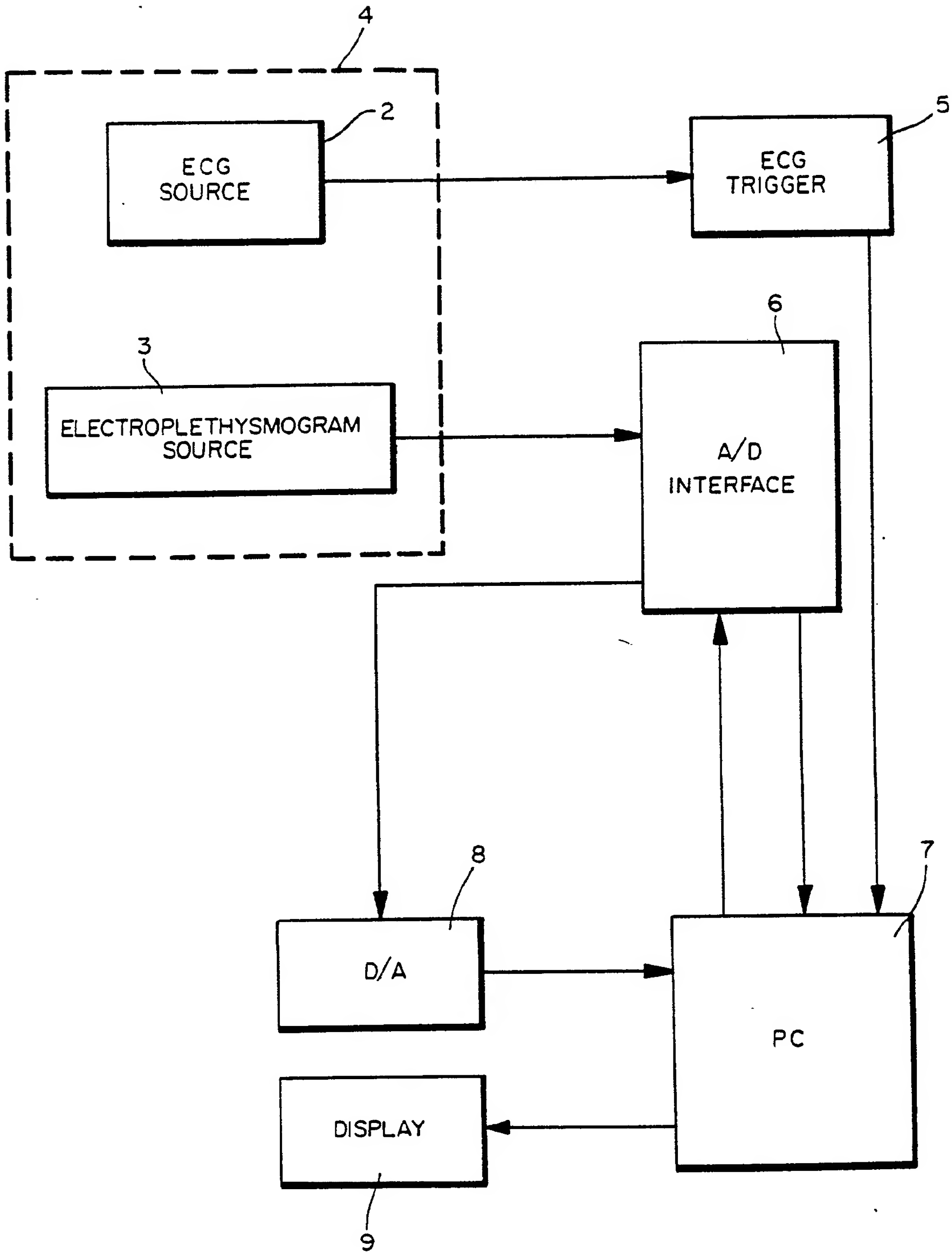


FIG. 2
PRIOR ART

FIG. 3


4
2
ECG SOURCE
3
ELECTROPLETHYSMOGRAM SOURCE
5
ECG TRIGGER
6
A/D INTERFACE
8
D/A
7
PC
DISPLAY
9

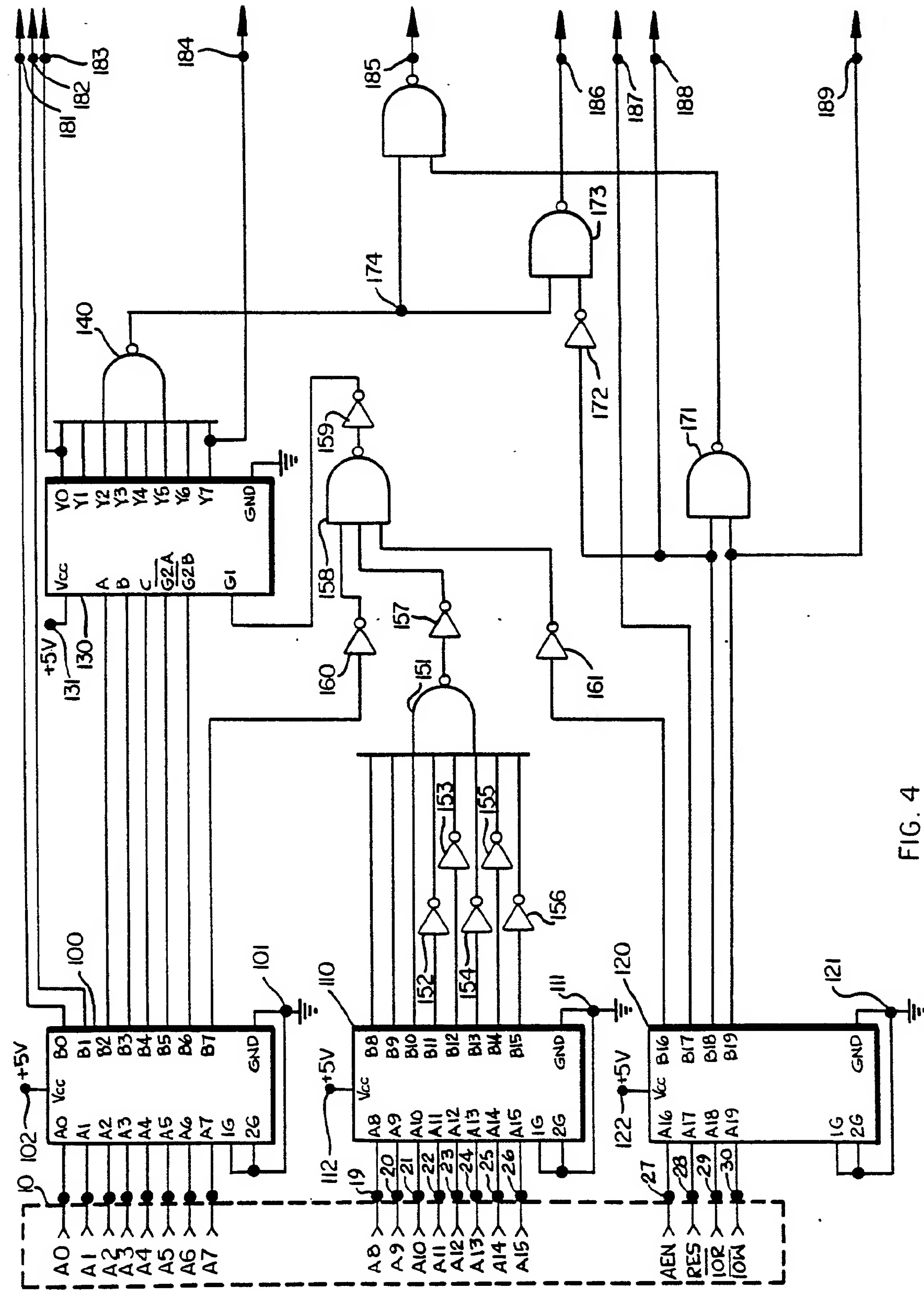

181
182
183
184
185
186
187
188
189
140
174
173
172
171
159
158
157
160
161
151
152
153
154
155
156
130
131
+5V
Y0 Y1 Y2 Y3 Y4 Y5 Y6 Y7 GND
Vcc A B C G2A G2B G1
100
101
102
110
111
112
120
121
122
B0 B1 B2 B3 B4 B5 B6 B7 GND
Vcc A0 A1 A2 A3 A4 A5 A6 A7 1G 2G
B8 B9 B10 B11 B12 B13 B14 B15 GND
Vcc A8 A9 A10 A11 A12 A13 A14 A15 1G 2G
B16 B17 B18 B19 GND
Vcc A16 A17 A18 A19 1G 2G
10
19 20 21 22 23 24 25 26
27 28 29 30
A0 A1 A2 A3 A4 A5 A6 A7
A8 A9 A10 A11 A12 A13 A14 A15
AEN RES IOR IOW

FIG. 4

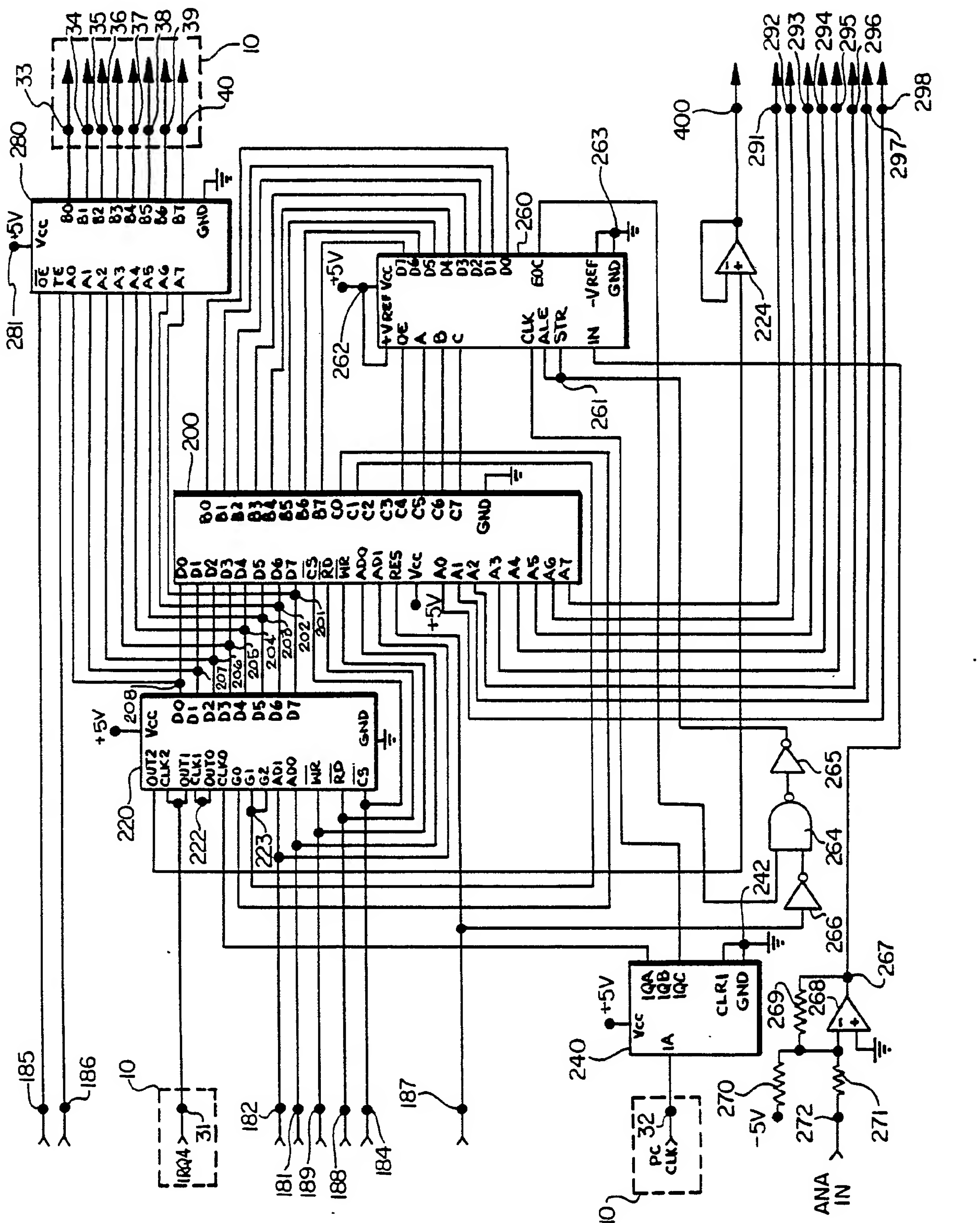


FIG. 5

FIG. 6

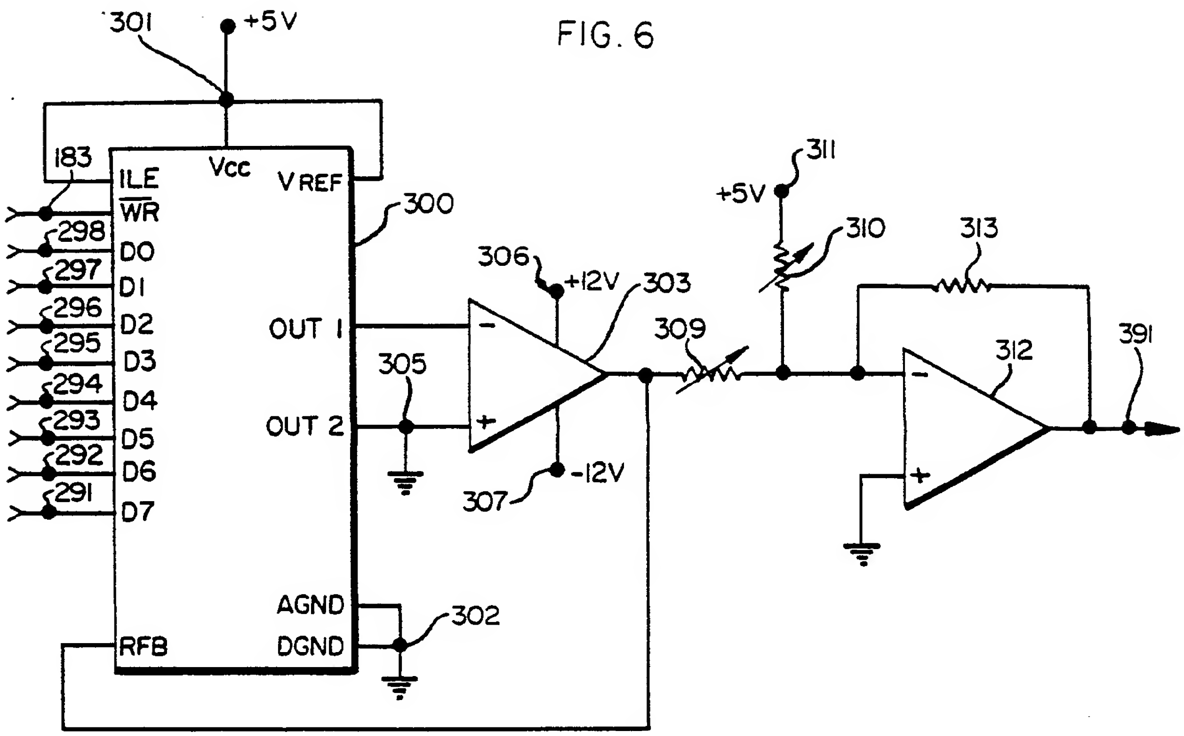

301
+5V
183
ILE
WR
Vcc
VREF
300
298
D0
297
D1
296
D2
295
D3
294
D4
293
D5
292
D6
291
D7
OUT 1
OUT 2
AGND
DGND
RFB
302
305
306
+12V
303
-12V
307
309
311
+5V
310
313
312
391

FIG. 7

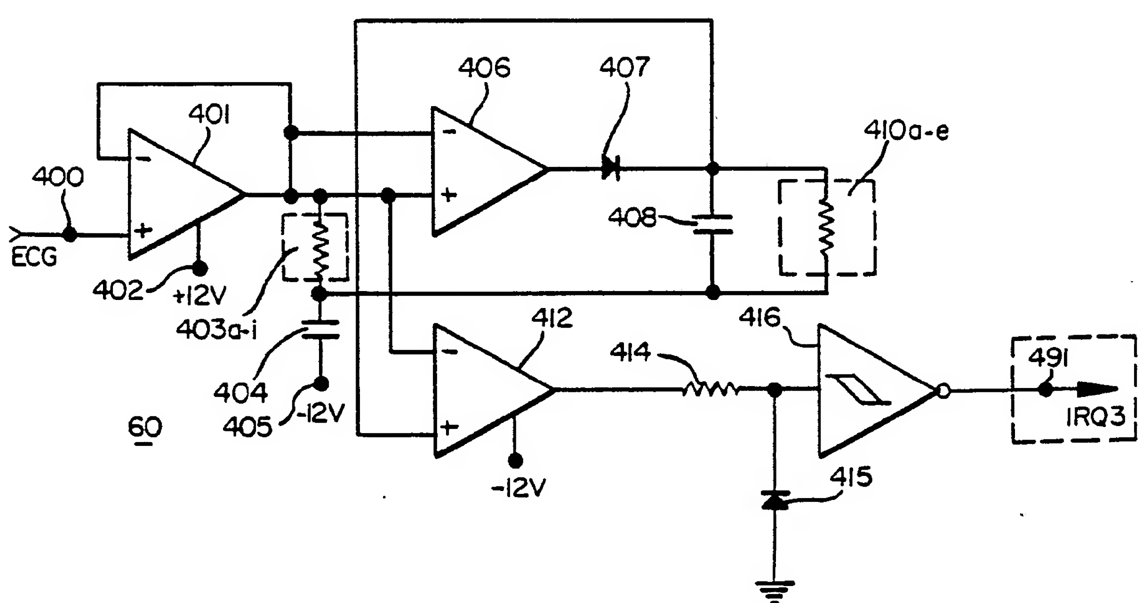

406
407
401
410a-e
400
ECG
408
402
+12V
403a-i
412
414
416
491
IRQ3
404
405
-12V
60
-12V
415

FIG. 8

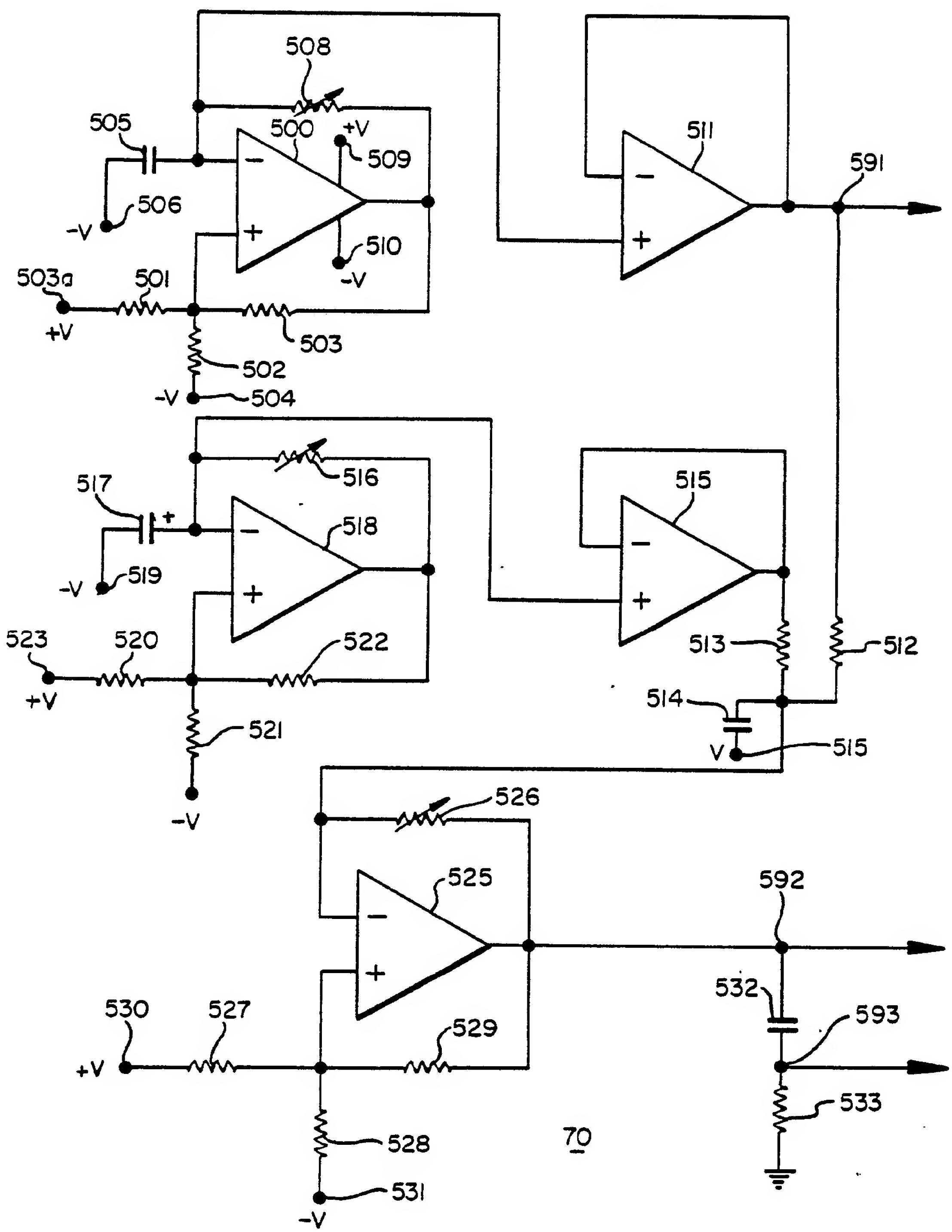
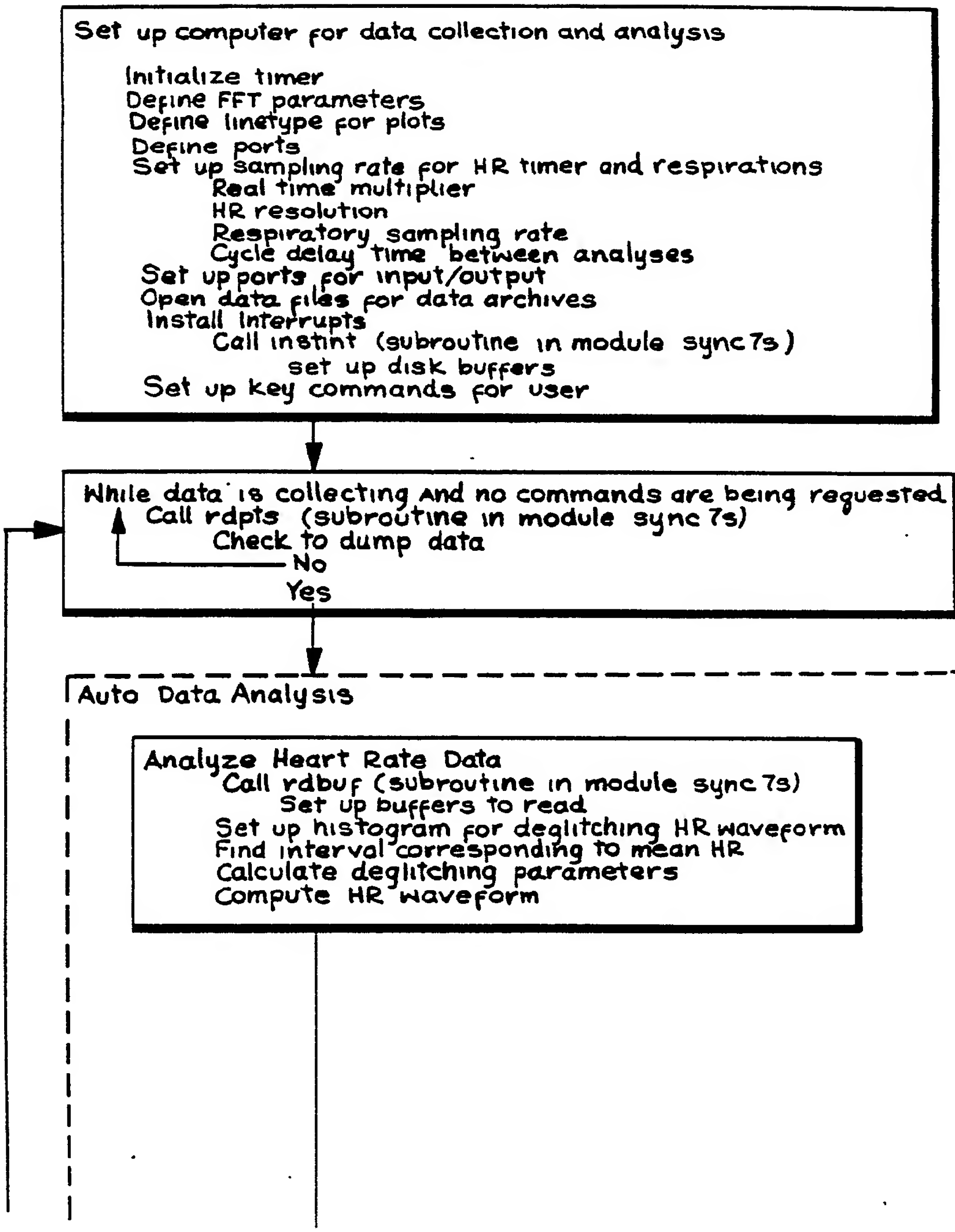

508
505
500
+V
509
511
591
506
-V
510
-V
503a
501
+V
503
502
-V
504
516
517
+
518
515
519
-V
523
520
522
+V
513
512
514
521
V
515
-V
526
525
592
532
593
530
527
529
+V
533
528
70
531
-V

FIG. 9A


Set up computer for data collection and analysis
Initialize timer
Define FFT parameters
Define linetype for plots
Define ports
Set up sampling rate for HR timer and respirations
Real time multiplier
HR resolution
Respiratory sampling rate
Cycle delay time between analyses
Set up ports for input/output
Open data files for data archives
Install interrupts
Call instint (subroutine in module sync7s)
set up disk buffers
Set up key commands for user
While data is collecting and no commands are being requested
Call rdpts (subroutine in module sync7s)
Check to dump data
No
Yes
Auto Data Analysis
Analyze Heart Rate Data
Call rdbuf (subroutine in module sync7s)
Set up buffers to read
Set up histogram for deglitching HR waveform
Find interval corresponding to mean HR
Calculate deglitching parameters
Compute HR waveform

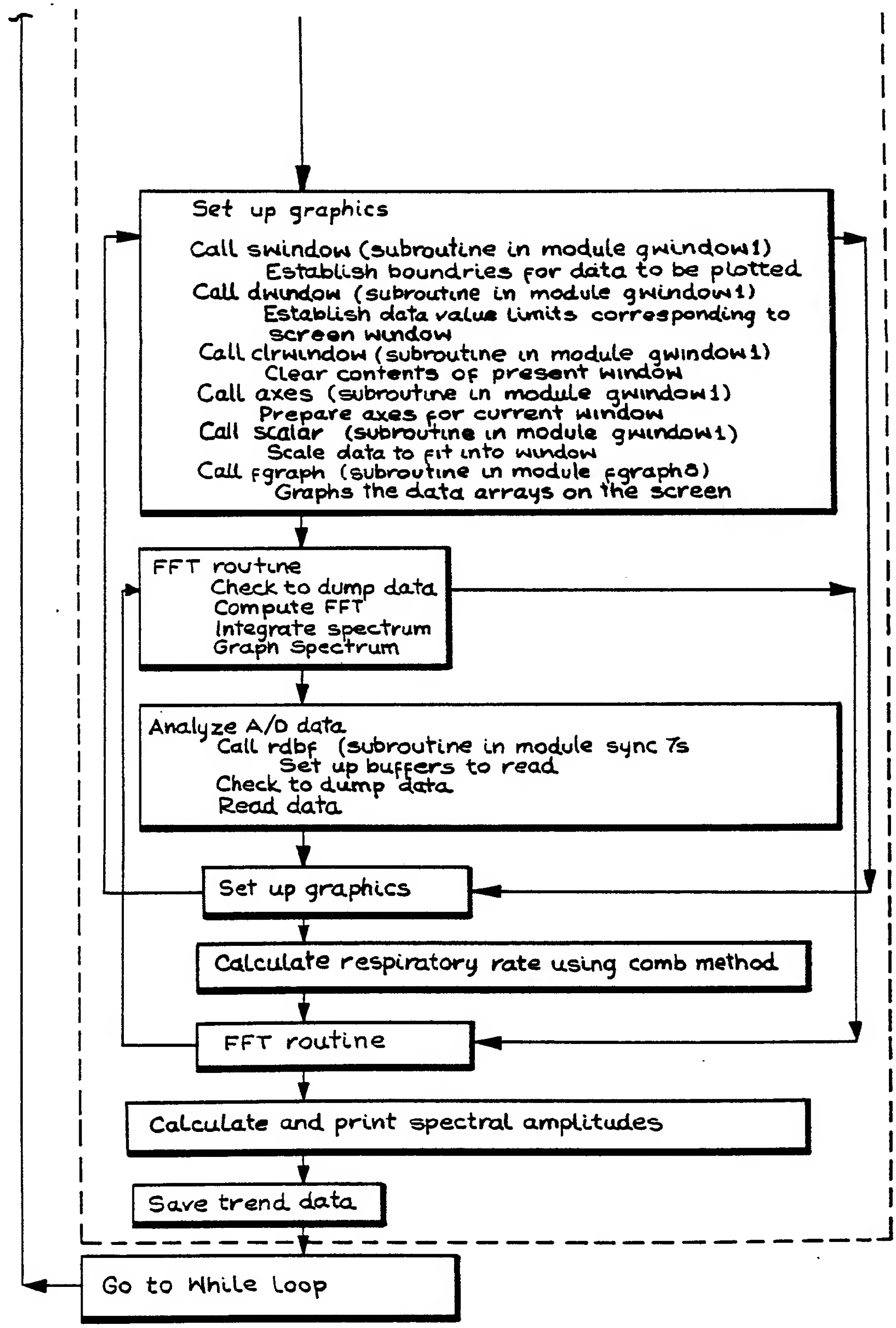

Set up graphics
Call swindow (subroutine in module gwindow1)
Establish boundries for data to be plotted
Call dwindow (subroutine in module gwindow1)
Establish data value limits corresponding to screen window
Call clrwindow (subroutine in module gwindow1)
Clear contents of present window
Call axes (subroutine in module gwindow1)
Prepare axes for current window
Call scalar (subroutine in module gwindow1)
Scale data to fit into window
Call fgraph (subroutine in module fgraph8)
Graphs the data arrays on the screen
FFT routine
Check to dump data
Compute FFT
Integrate spectrum
Graph Spectrum
Analyze A/D data
Call rdbf (subroutine in module sync 7s
Set up buffers to read
Check to dump data
Read data
Set up graphics
Calculate respiratory rate using comb method
FFT routine
Calculate and print spectral amplitudes
Save trend data
Go to While Loop

FIG. 9B

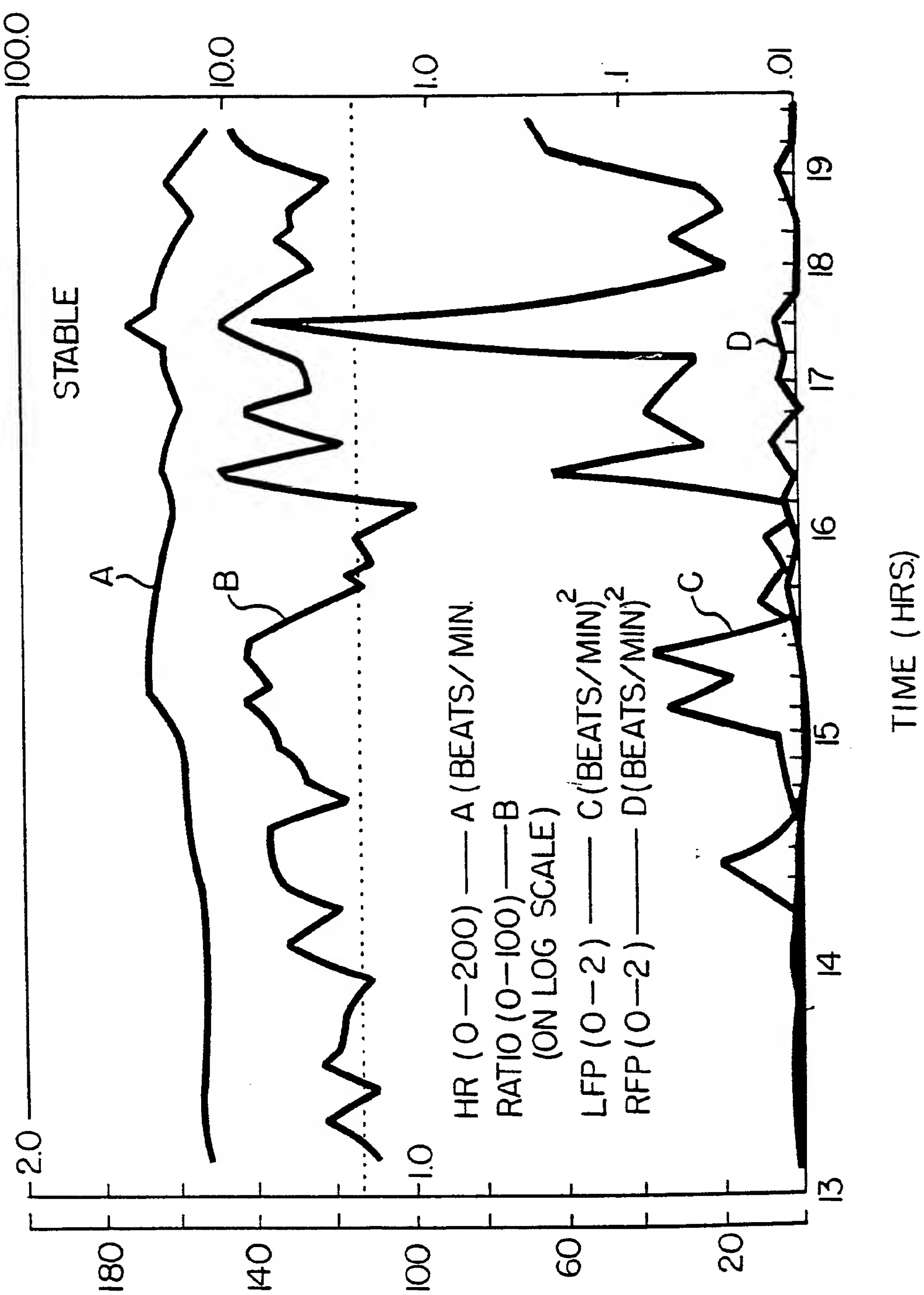

STABLE
A
B
C
D
HR (O—200) —— A (BEATS/MIN.
RATIO (O—100) —— B
(ON LOG SCALE)
LFP (O—2) —— C (BEATS/MIN)2
RFP (O—2) —— D (BEATS/MIN)2
TIME (HRS)
13
14
15
16
17
18
19
180
140
100
60
20
2.0
1.0
100.0
10.0
1.0
.1
.01

FIG. 10

FIG. II

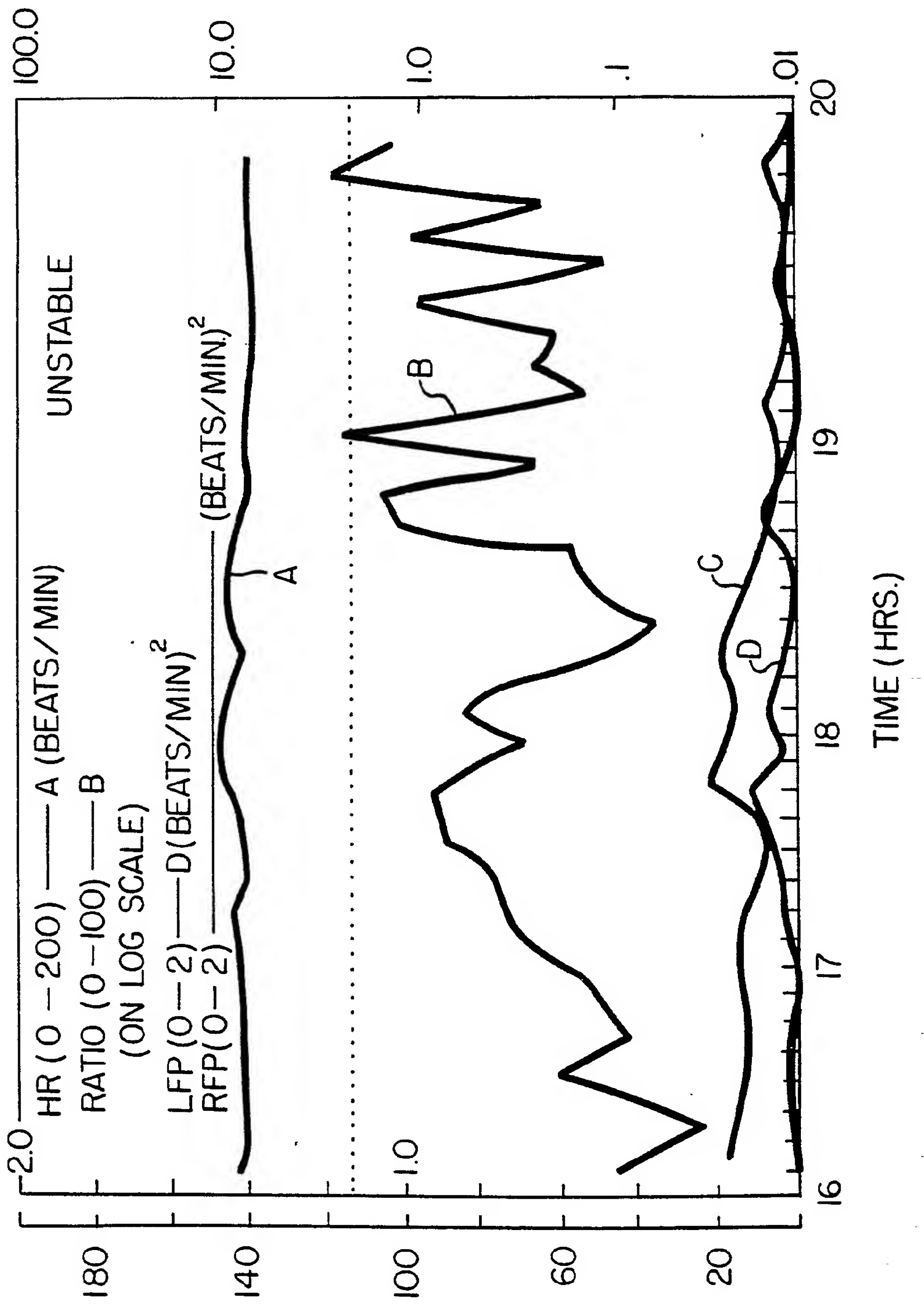

HR (0 – 200) —— A (BEATS/MIN)
RATIO (0–100) —— B
(ON LOG SCALE)
LFP (0–2) —— D (BEATS/MIN)²
RFP (0–2) —— (BEATS/MIN)²
UNSTABLE
A
B
C
D
2.0
1.0
180
140
100
60
20
100.0
10.0
1.0
.1
.01
16
17
18
19
20
TIME (HRS.)

FIG.12

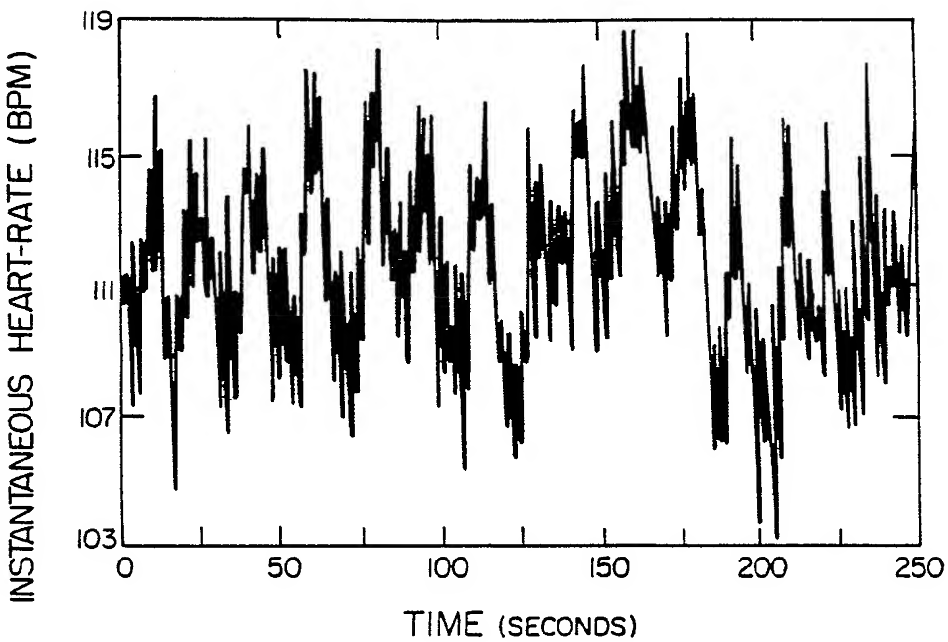

119
115
111
107
103
INSTANTANEOUS HEART-RATE (BPM)
0
50
100
150
200
250
TIME (SECONDS)

FIG.13

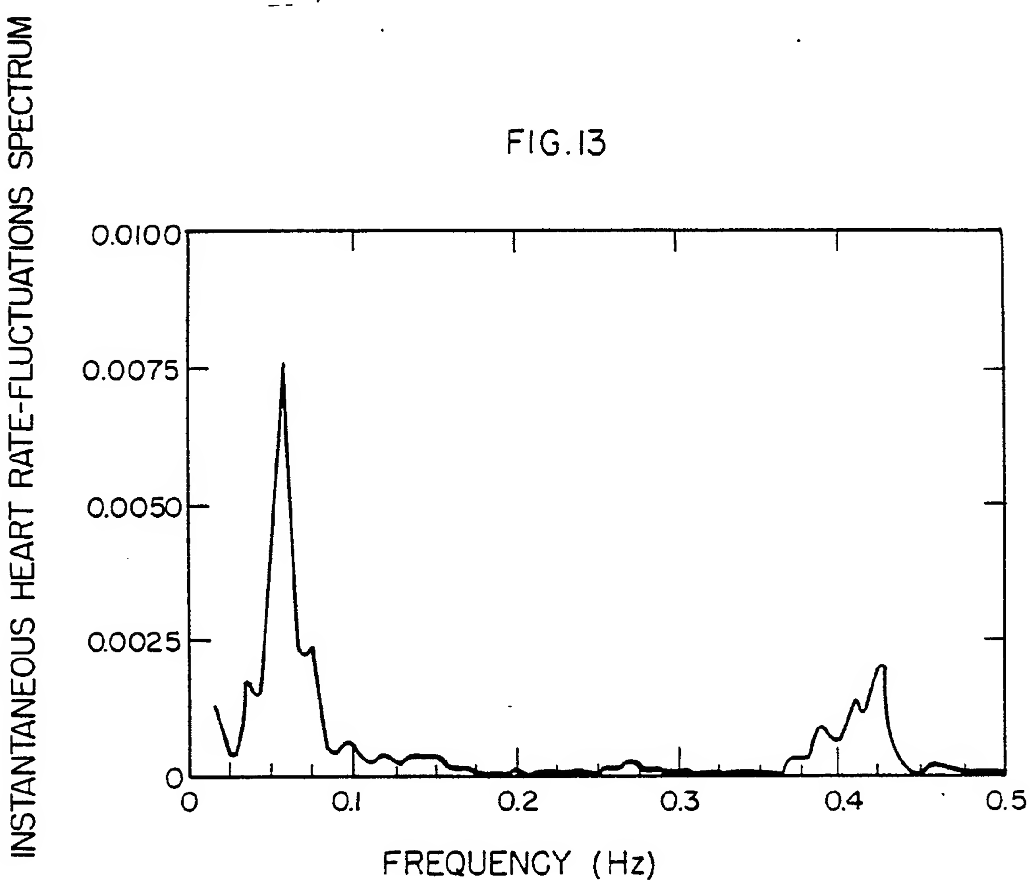
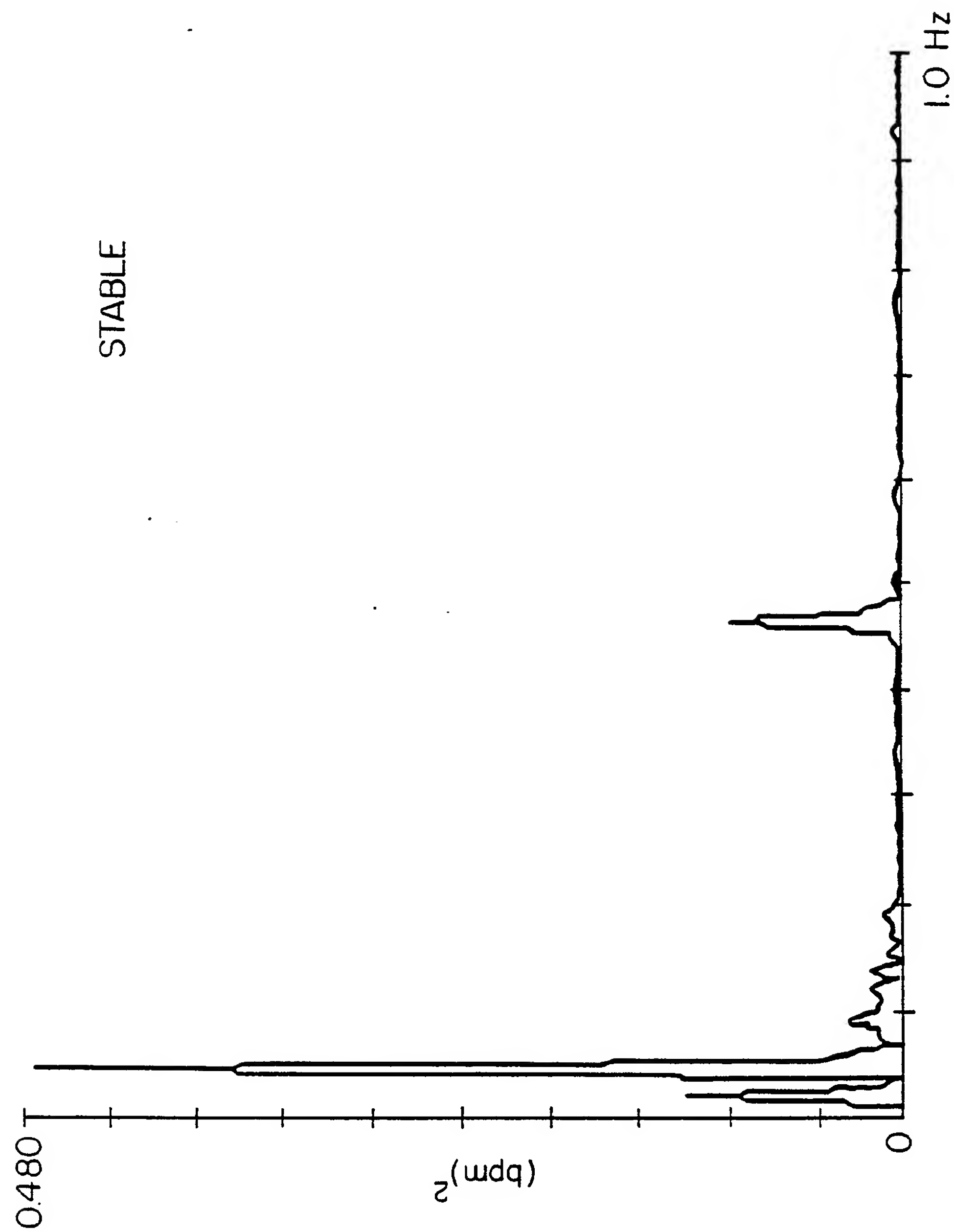

0.0100
0.0075
0.0050
0.0025
0
INSTANTANEOUS HEART RATE-FLUCTUATIONS SPECTRUM
0
0.1
0.2
0.3
0.4
0.5
FREQUENCY (Hz)

FIG. 14



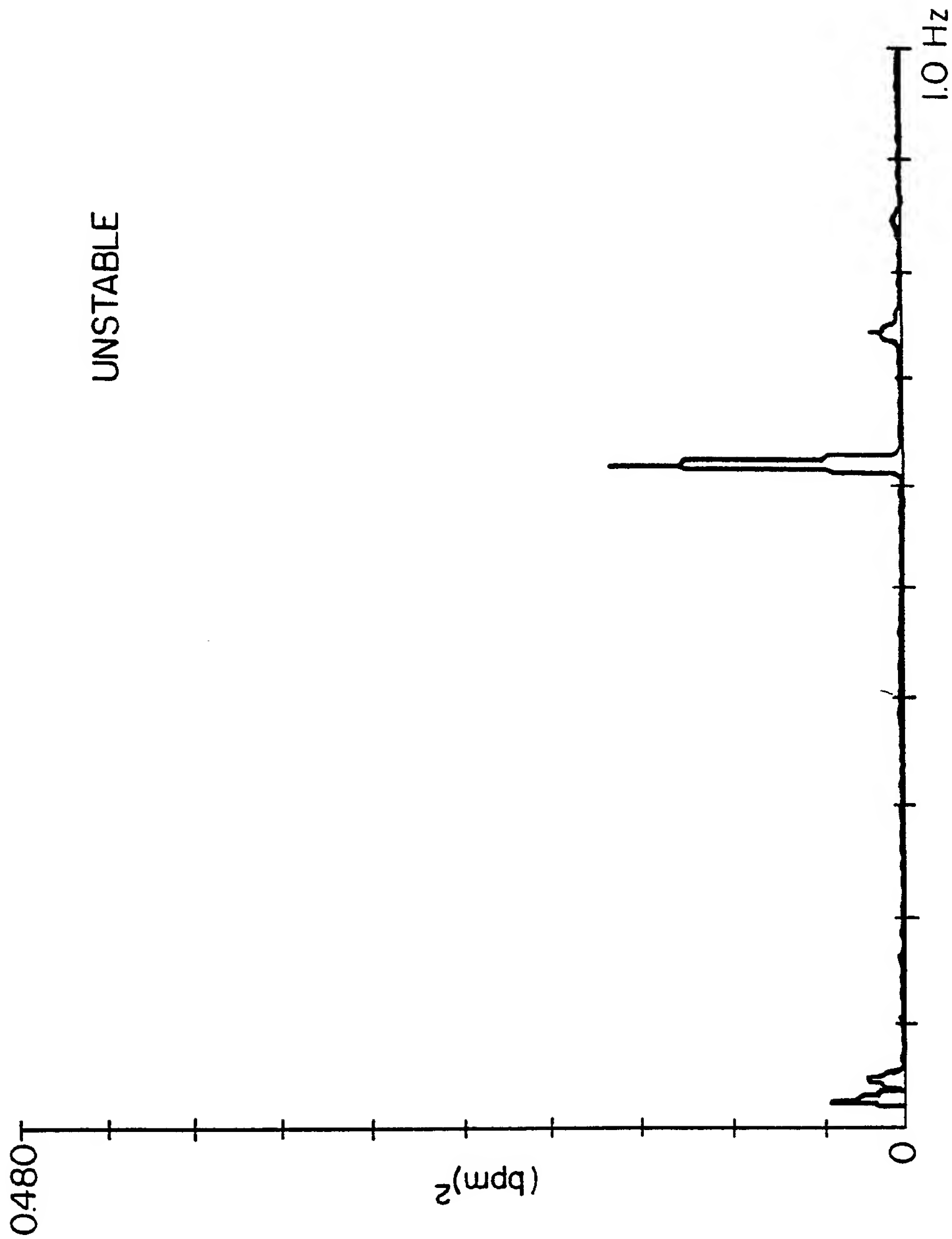
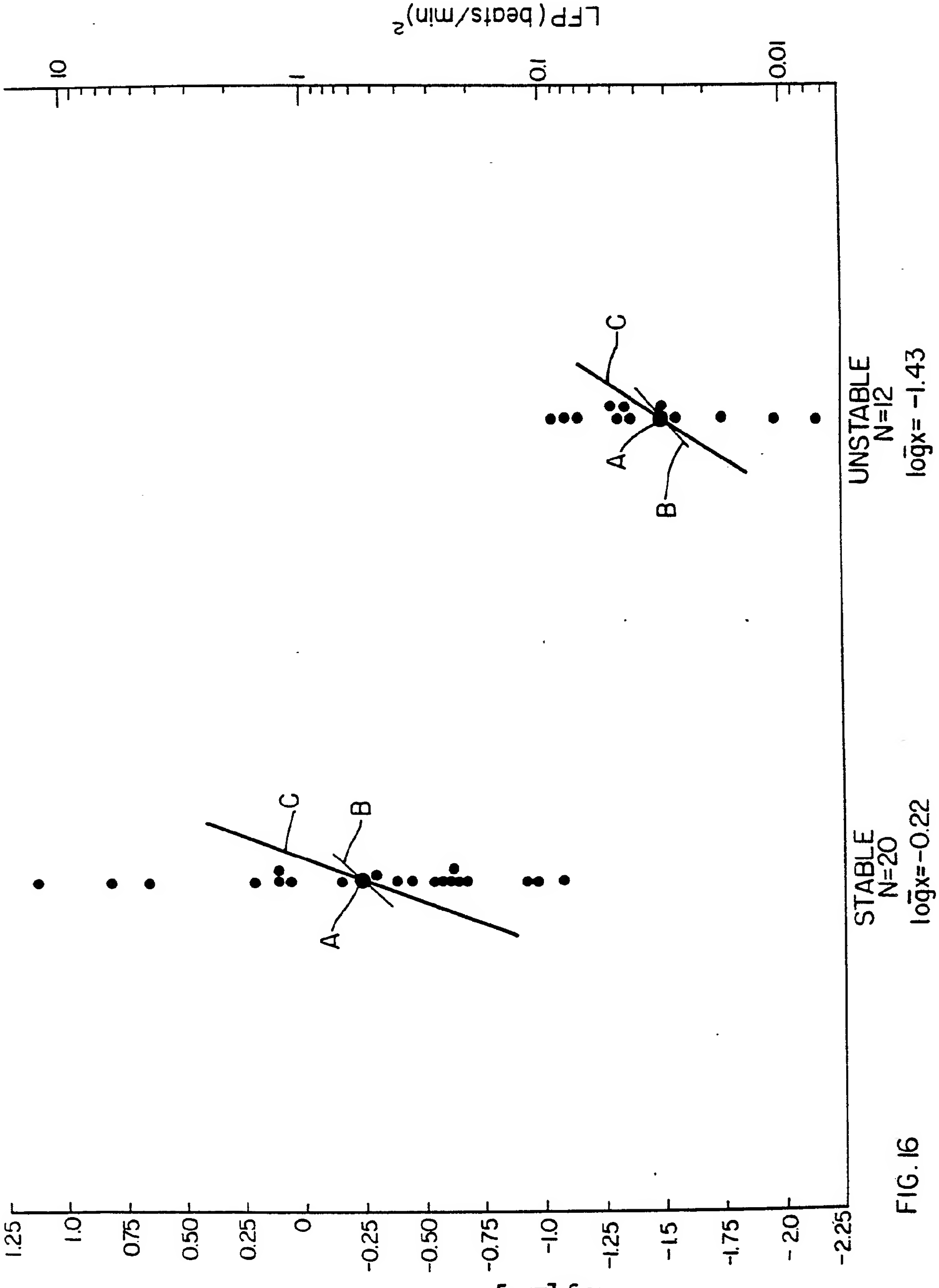


FIG. 15



LFP (beats/min)^2
10
1
0.1
0.01
log [LFP]
1.25
1.0
0.75
0.50
0.25
0
-0.25
-0.50
-0.75
-1.0
-1.25
-1.5
-1.75
-2.0
-2.25
A
B
C
STABLE
N=20
$\log \bar{x}=-0.22$
UNSTABLE
N=12
$\log \bar{x}= -1.43$

FIG. 16

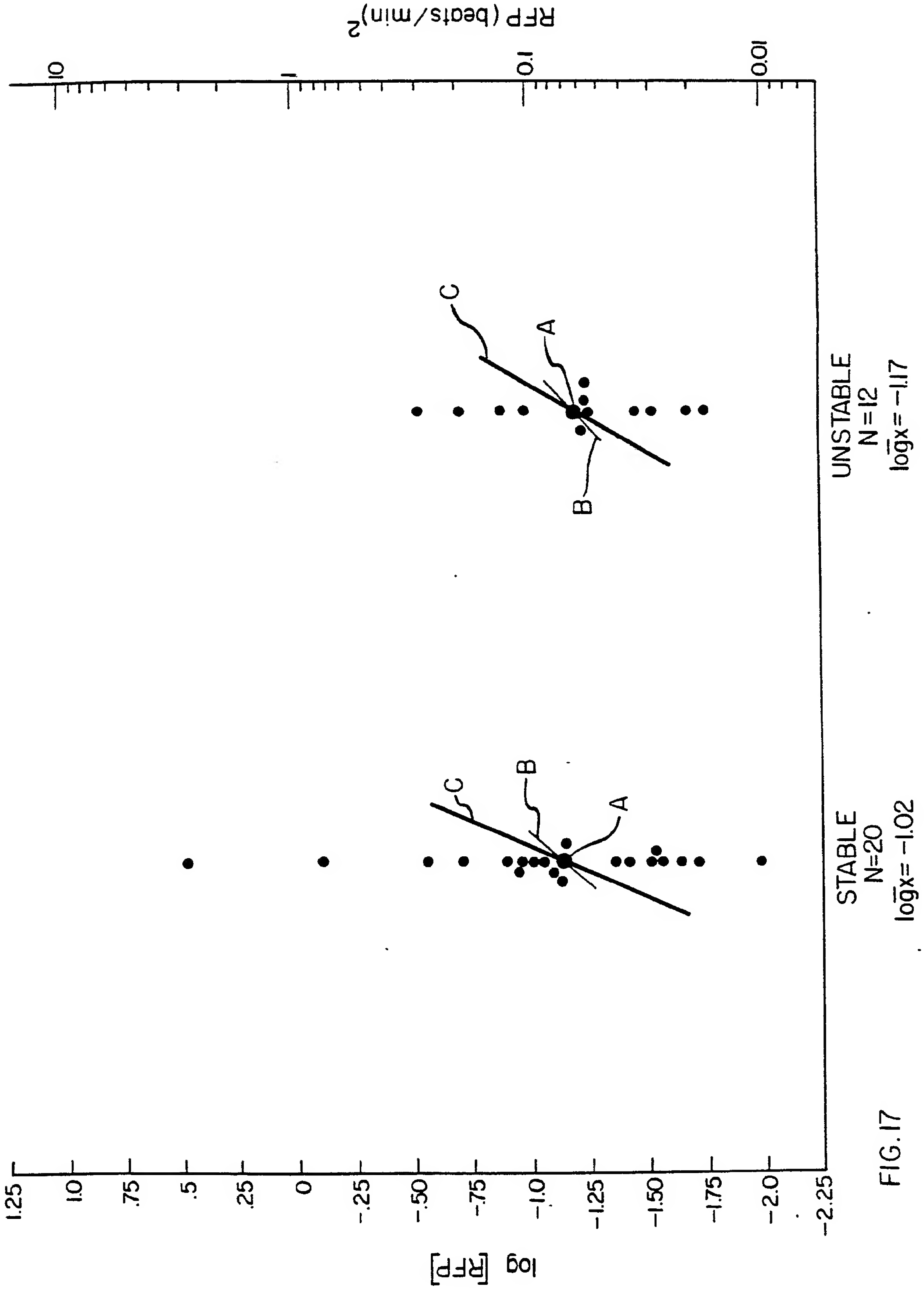

RFP (beats/min)^2
10
1
0.1
0.01
log [RFP]
1.25
1.0
.75
.5
.25
0
-.25
-.50
-.75
-1.0
-1.25
-1.50
-1.75
-2.0
-2.25
A
B
C
STABLE
N=20
$\log\bar{x}$= -1.02
UNSTABLE
N=12
$\log\bar{x}$= -1.17

FIG.17

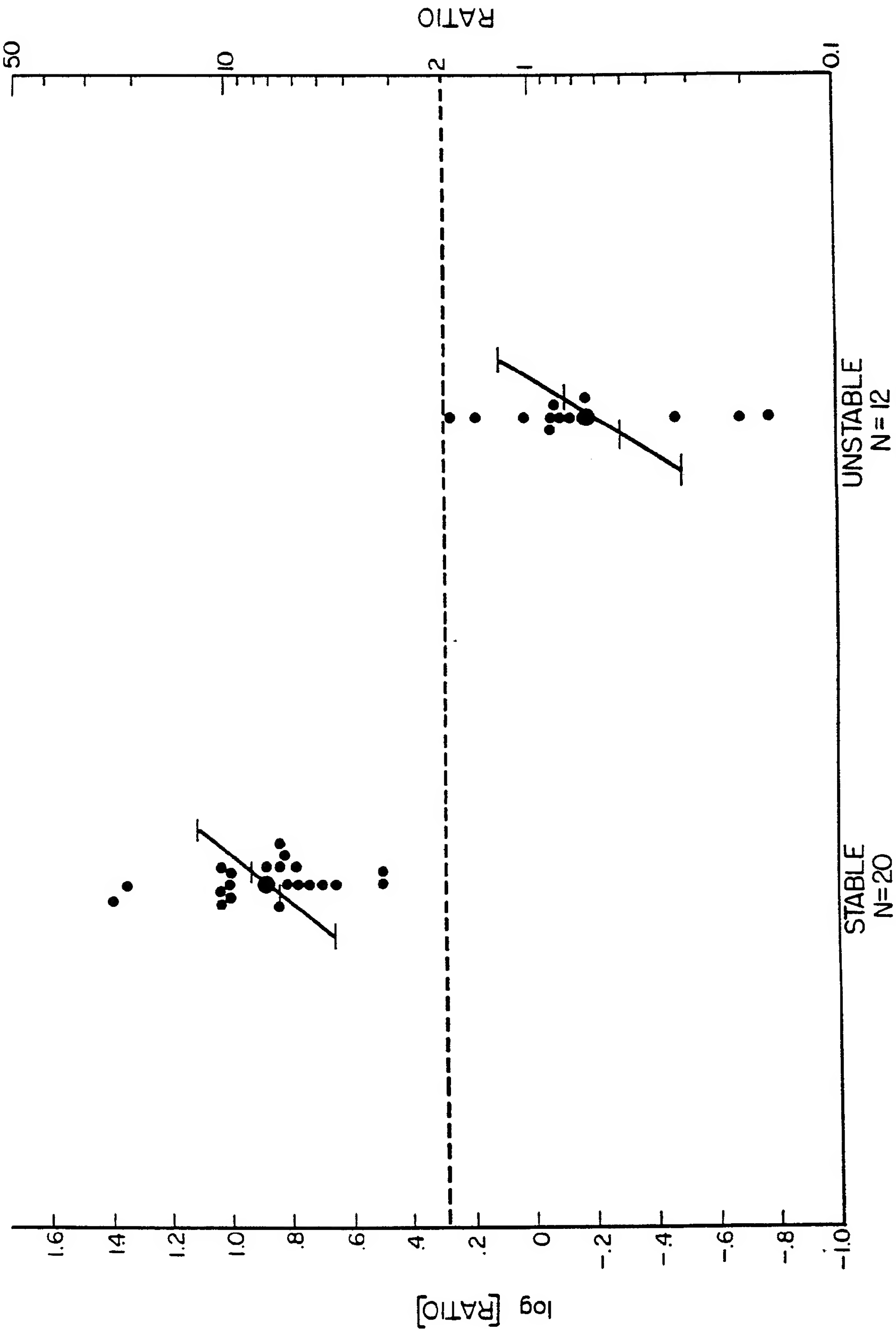

RATIO
50
10
2
1
0.1
log [RATIO]
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
-.2
-.4
-.6
-.8
-1.0
STABLE
N=20
$\overline{X}$ = 8.77
UNSTABLE
N=12
$\overline{X}$ = 0.83

FIG.18

INTERNATIONAL SEARCH REPORT

International Application No PCT/US86/01193

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4): A61B 5/02
US Cl: 128/671

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	128/671,695,696,702,725 364/415,417

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [6]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	US,A, 4,379,460 (JUDELL) 12 APRIL 1983 See entire document	
A	US,A, 4,422,458 (KRAVATH) 27 DECEMBER 1983 See entire document	
A	US,A, 4,463,764 (ANDERSON et al) 7 AUGUST 1984 See entire document	
A	US,A, 4,506,678 RUSSELL et al) 26 MARCH 1985 See entire document	
A	US,A, 4,519,395 (HRISHESKY) 28 MARCH 1985 See entire document	
A	DE,A, 2,527,475 (HOFMANN et al) 30 DECEMBER 1976 See entire document	
A	JOURNAL OF CLINICAL ENGINEERING, volume 5, number 1, issued JANUARY-MARCH 1980 (QUEST PUBLISHING CO.), J.R. PUTNAM et al, "ECG/RESPIRATION MONITOR CALIBRATOR". See entire document	

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
4 AUGUST 1986	13 AUG 1986
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	W.E. KAMM

International Application No. PCT/US86/01193

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	MEDICAL AND BIOLOGICAL ENGINEERING AND COMPUTING, volume 20, number 3, issued MAY 1972, "A.J. WILSON et al, "METHODS OF FILTERING THE HEART-BEAT ARTIFACT FROM THE BREATHING WAVEFORM OF INFANTS OBTAINED BY IMPEDANCE PNEUMOGRAPHY". See entire document	

V.☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1.☐ Claim numbers .... because they relate to subject matter [12] not required to be searched by this Authority, namely:

2.☐ Claim numbers..........., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI.☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1.☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4.☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.